INSTRUMENTS AND CONTROL SYSTEMS

INCLUDING: JOURNAL OF THE SCMA • PRECISION MEASUREMENTS ASSOCIATION • SIMULATION COUNCIL NEWSLETTER

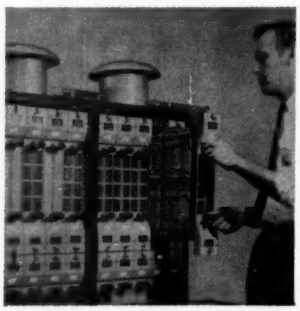
MARCH 1961

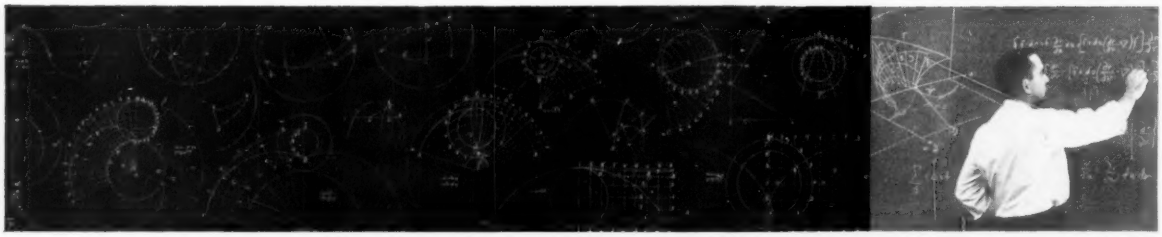
in this issue:

Thin-Film Memories 451
Optical Systems 455
Programming Dynamic Tests 463
Reference and Working Electrical Standards 475
Standards Laboratory 478
Continuous Stream Analyzers 481

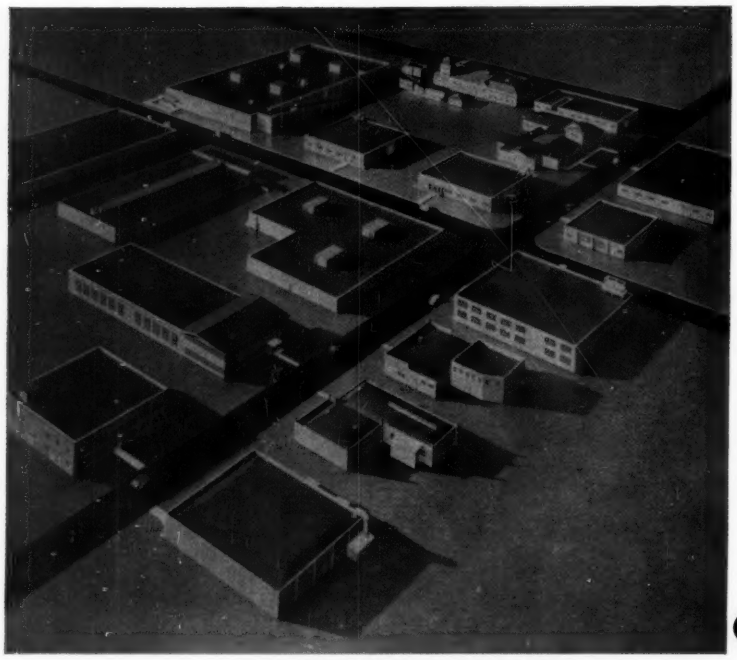
LIBRASCOPE COMPUTER FACILITIES

Shown below is a composite view of Librascope's facilities where a variety of computer systems are currently in different stages of design and production. Some are strategically involved with national defense...others deal with business and industrial process control. Each is uniquely designed to answer a particular need. The success of these systems illustrates the value of Librascope's engineering philosophy: A decentralized organization of specialized project teams responsible for assignments from concept to delivery...and backed up by excellent research, service, and production facilities. For your computer requirements, call on the company whose breadth of diversification in computer technology is unsurpassed. ■ Librascope Division, General Precision, Inc., 808 Western Avenue, Glendale, Calif. For career opportunities write to John Schmidt, Engineering Employment. ■





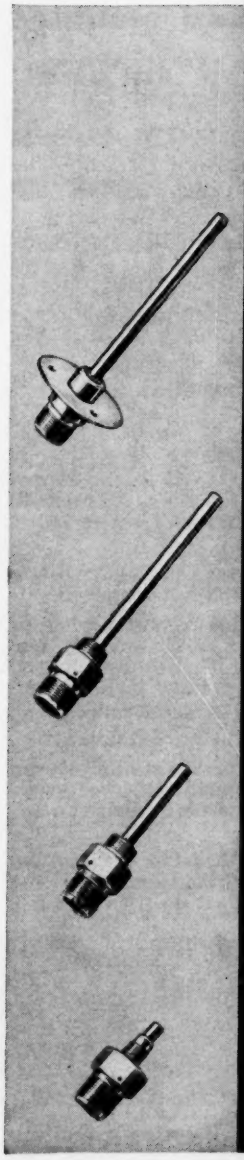
computers that pace man's expanding mind



CIRCLE 1 ON READER-SERVICE CARD

RESISTANCE *type* TEMPERATURE DETECTORS

By **LEWIS**



QUALIFIED, precisely wound, individually calibrated units that meet or exceed the requirements of:

- MIL-B-8596 (ASG)
- MIL-T-25445B (USAF)
- MIL-B-7990A
- MIL-B-7258 (USAF)
- MIL-B-7370A
- MIL-B-5491A (Aer)

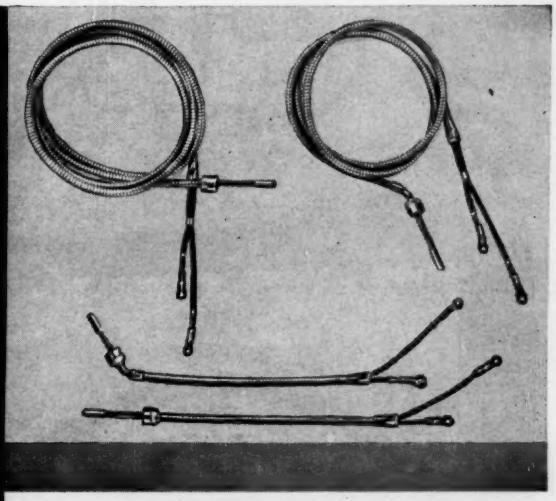
SPECIALLY DESIGNED temperature detectors for use in modern jet and piston-powered aircraft, made to the Airframe Manufacturer's specifications for sensing the temperatures of:

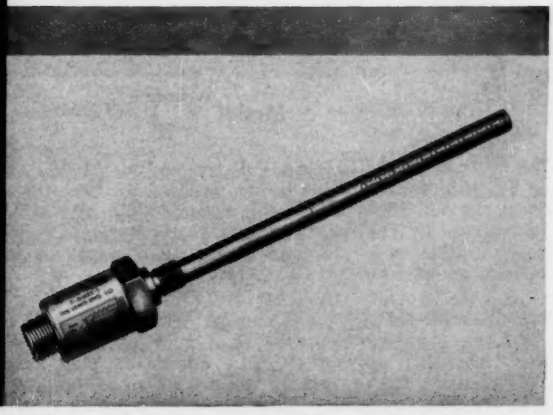
- FUEL TANKS
- FREON SYSTEMS
- HYDRAULIC SYSTEMS
- CYLINDER HEADS
- CABIN AIR
- ENGINE OIL
- FUEL AT ENGINES
- OUTSIDE AIR
- HEATER DUCTS
- RAM AIR
- GENERATOR-DRIVE UNITS

PLATINUM-WOUND TRANSDUCERS for use in MISSILES, to measure the temperatures of:

- LIQUID OXYGEN
- COMBUSTION GAS
- HELIUM
- AIR

and other media to customer's specifications





FOR AIRCRAFT AND MISSILES

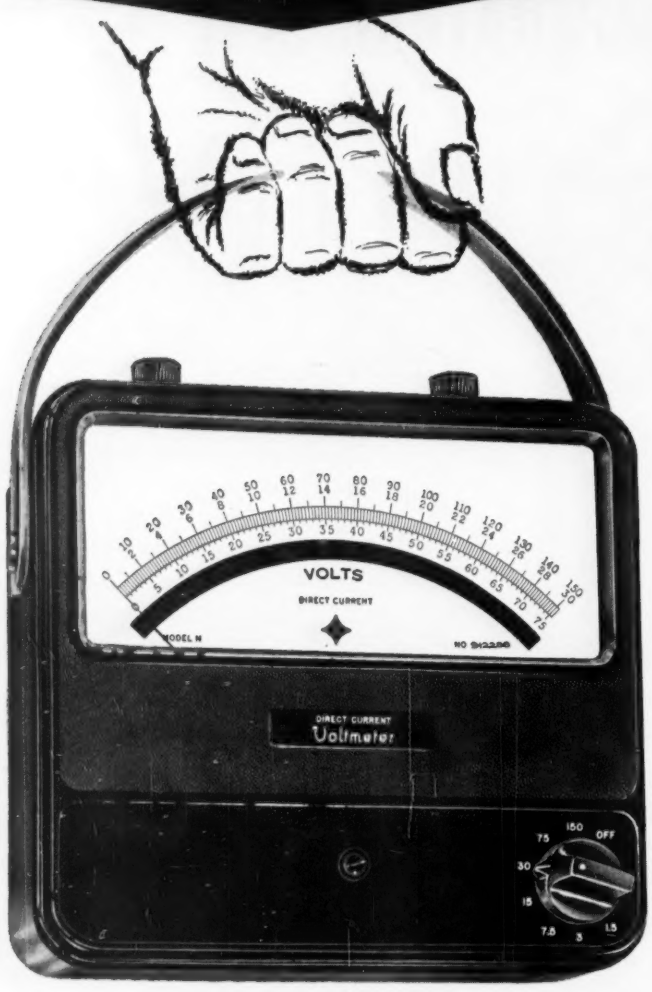
THE LEWIS ENGINEERING COMPANY

NAUGATUCK, CONNECTICUT

Specialists In Temperature Measurement

CIRCLE 2 ON READER-SERVICE CARD

SENSITIVE RESEARCH



Model "N"

THE *New* MODEL "N"

A new series of AC and DC portable electrical indicating instruments — *that can also be panel mounted.*

A *New* HIGH in accuracy, resolution, and stability.

A *New* LOW in cost.

In short, the SRIC Model "N" series probably has just the instrument for which you've been looking **HIGH** and **LOW**. The Model "N" is a true "secondary standard" because it is engineered and manufactured by "standards people."

GENERAL SPECIFICATIONS:

Accuracy: .5% of full scale.

Scale: Hand-drawn and mirrored.

Scale length: 6".

Resolution: 100 to 150 division.

Ranges: DC from 50 ua. to 50 A. and 20 mv. to 1000 v. full scale. AC from 10 ma. to 10 A. and 7.5 v. to 750 v. full scale.

Availability: 1 to 8 ranges completely switch-controlled and self contained.

Construction: DC — double pivoted permanent magnet type. AC — moving iron vane for RMS measurements and germanium rectifier type for average reading measurements.

Shielding: Magnetic and electrostatic.

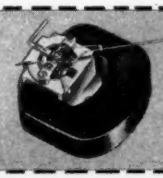
Pivots and Jewels: High carbon steel pivots and shock mounted sapphire jewels. (Diamond pivots available on special order).

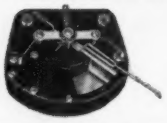
Case: Black moulded bakelite with leather carrying handle. Size 7½" x 6¾" x 3½".

The *New* Model "N" is a stable, rugged, versatile field or laboratory instrument that is *spectacular* because in every way it offers a little bit "more" than any other instrument in its class. It is available in standard range combinations or in quantities with special ranges and/or special scale markings.

The New* Model "N" *conforms to ASA specs. C 39.1-1951 for .5% class instruments. All SRIC instruments are calibrated against primary standards that have National Bureau of Standards Certificates of Accuracy and are unconditionally guaranteed for a period of one year.

The movement construction shown features a large size U-shaped magnet with an inherently high torque-to-weight ratio, stability and sensitivity — and *not* the common center core magnet usually found in instruments in its price range.





AC INSTRUMENTS UTILIZE A FAST-ACTING, RUGGED, MOVING IRON-VANE MOVEMENT

SENSITIVE RESEARCH INSTRUMENT CORPORATION

Symbol of Quality

NEW ROCHELLE, N. Y. — ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

CIRCLE 3 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS

Optics and programming are the subjects of major emphasis this month.

VOLUME 34, NUMBER 3, MARCH 1961

PRINT ORDER THIS MONTH 43,000

EDITORIAL

Scientific and Process Control Instrument Industries Outlook for 1961 and Review of 1960 449

FEATURE ARTICLES

Thin-Film Memories 451

ERIC E. BITMANN—No. 4 in memory series covers principles and advantages of thin-film memories

Optical Systems 455

MILTON LAIKIN—Factors include glass type, striae, anneal, stain, and surface quality. Lenses, mirrors and flats are covered

DC-Voltage Control Signals 460

DONALD T. CUSACK—Why Hagan uses dc-voltage type control signals, including transmission-line effects

Programming Dynamic Tests 463

G. B. KUBICECK—An adjustable function generator using the Varnistat as its basic element

Accelerometer Calibration 467

LAWRENCE MOSKOWITZ—Part 2—techniques for measuring the ouptut of an accelerometer

Monitor Scans 5000 Inputs/Second 472

LEIGHTON A. MEEKS—This system permits a nuclear reactor to be operated just a few degrees from "scram"

Journal of the Precision Measurements Association 475

REFERENCE and WORKING ELECTRICAL STANDARDS—Suggested Practices by F. B. Silsbee

Independent Standards Laboratory 478

Another link between the NBS and all manufacturers and researchers who use precision instruments

INSTRUMENTS AND CONTROL SYSTEMS

VOL. 34 NO. 3
MARCH 1961

Journal of the Southern California Meter Association 480

CONTINUOUS STREAM ANALYZERS by ROBERT C. HOFFMAN. Covers typical analysis problems and results, in isobutane recovery, moisture monitoring, control, etc.

Interference Comparator 485

DR. JURGEN WITTHOFT—A comparator of the Duhmke type for gage blocks

Simulation Council Newsletter 487

Rocky Mountain Meeting of 5 Dec. on Euler Angles

Transfer Functions and Environment Simulation 487

Eastern Meeting of 12 Dec. at Computer Systems 489

SCI Activities 494

Recording of Intervals on a Multi-Pen Recorder 497

EDWARD B. YONTEF and HERBERT M. JENKINS. A technique for obtaining resolution without increasing chart speed

Pulse Analysis by Histogram 498

V. J. CAGGIANO—Analysing the frequency distribution of pulse-type signals via a "time basket"

OTHER REGULAR FEATURES

Letters to the Editor 378
Inquiries 381
Books 389
News 390
New Applications ..392
Stock Report 394
Trends 417
Panhandle Pete 430
Briefs 432
Annual Events Calendar 444
New Instruments 500
New Literature 544
Searchlite Section 548
Industry News 549
Advertisers' Index 550
Inquiry Card 551
Product Index 552

INSTRUMENTS PUBLISHING COMPANY, publishers to the Instruments and Control Systems industry with four publications:

INSTRUMENTS AND CONTROL SYSTEMS; INSTRUMENT & APPARATUS NEWS; MILITARY SYSTEMS DESIGN; MEDICAL ELECTRONICS NEWS

DISTRICT OFFICES

Richard Rimbach, Jr., Vice-President, Sales, New York, Murray Hill 8-0980
Boston 16, Mass., Harold H. Short, Jr., 269 Main St., Stoneham, 438-3982
Chicago 6, Ill., Harold W. Haskett, Madison Terminal Bldg., 9 South Clinton St., Central 6-8963
Clearwater, Florida, E. F. Nordstrom, 1651 Sherwood St., Clearwater 441-9033
Cleveland (Shaker Heights 22), Ohio, Max G. Bauer, 3310 Warrensville Center Rd., Wyoming 1-7145
Los Angeles 34, Calif., John Fahey, 2639 S. La Cienga Blvd., Upton 0-8442
New York 17, N. Y., Richard Rimbach, Jr., 525 Lexington Ave., Rm. 359, Murray Hill 8-0980
Pittsburgh 12, Penna., C. F. Goldcamp, 845 Ridge Ave., Fairfax 10161
Philadelphia 4, Pa., Robert V. Frey, Suite 100, 101 N. 33rd St., Evergreen 2-3878
San Francisco 11, Calif., Charles Clark, 420 Market St., Douglas 2-3899
St. Louis 1, Mo., Steve Wright, Fred Wright Co., Room 416, 4 N. 8th St., Chestnut 1-1965
London, W. C. 2 England, John C. N. Hughes, T. C. Scott & Son Ltd., No. 1 Clement's Inn, Holborn 4743.

Richard Rimbach, Sr., Publisher

Richard Rimbach, Jr., Vice-President

Milton H. Aronson, Editorial Director

Fred D. Marton, Managing Editor

Robert C. Nelson, Sr. Assoc. Editor

James Emge, Assoc. Editor

Josephine Martin, Assoc. Editor

Robert E. Becko, Production Manager

Raymond C. E. Smith, Art Director

John M. McLeod, Jr., Editor, Simulation Council Newsletter Section

John M. Quirk, Editor, Journal Southern California Meter Association

C. F. Goldcamp, Manager, Research and Development

EXECUTIVE AND EDITORIAL OFFICES

Pittsburgh 12, Penna., 845 Ridge Ave., Fairfax 10161 or 19831

SUBSCRIPTION RATES

For One, Two, and Three Years

	One Year	Two Years	Three Years
United States, U.S. Possessions and Canada	$ 4.00	$ 7.00	$ 9.00
	(*Five Years* @ $10.00)		
Latin American	$ 6.00	$10.00	$14.00
All other countries	10.00	15.00	20.00

Position and company connection as well as products manufactured must be indicated in all subscription orders.

IBPA ABC

Payments from outside the U.S.A. must be in the form of an International Money Order or check on a U.S. Bank.

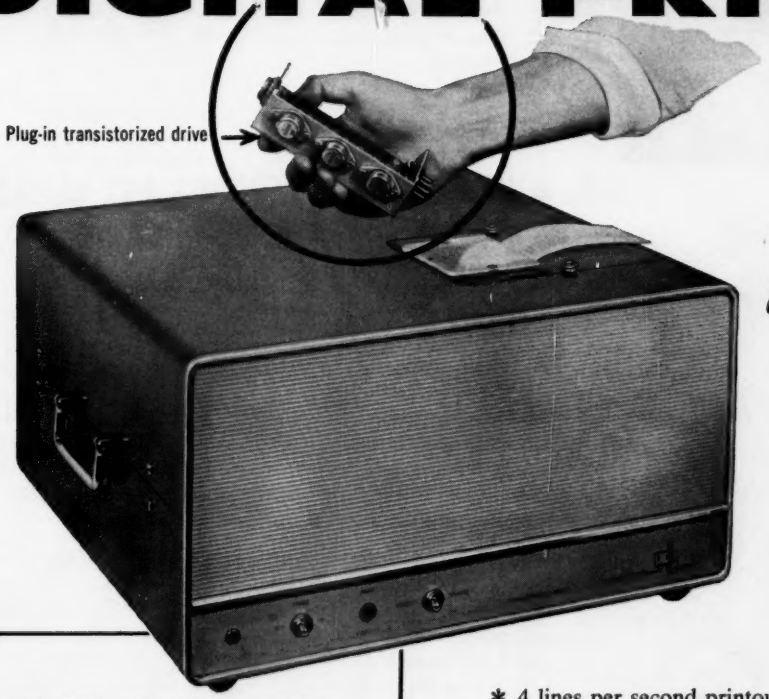
For change of address, give old as well as new address, include postal zone number. If possible enclose address label from magazine. Please allow one month for change.

Postmaster: Please send Form 3579 to Instruments & Control Systems, 845 Ridge Ave., Pittsburgh 12, Pa.

Instruments and Control Systems (including Instrument Manufacturing) published monthly by The Instruments Publishing Company, Inc. Office of publications, 1600 North Main Street, Pontiac, Illinois. Executive and Editorial Office, 845 Ridge Avenue, Pittsburgh 12, Pennsylvania. Second Class mail authorized at Pontiac, Illinois.

Copyright 1960 by Instruments Publishing Company, Inc.

solid state
DIGITAL PRINTER



the 400 CT-

The most versatile digital printer ever made

SPECIFICATIONS

Printout capacity	6 digits standard.
Accuracy	determined by basic counting instrument.
Display time	0.2 seconds minimum, maximum controlled by the counter.
Weight	60 lbs.
Power requirements	115 volts ±10%, 50-60 cps 25 watts
Dimensions	17" W x 8½" H x 16½" D. (Rack mounting available as option D.)
Warranty	One year on electronics; 1.5 million lines @ 4 lines per second on matrix; 10 million lines @ 4 lines per second on printer assembly, or 1 year, whichever occurs first.
Price	$1350.00. Add $10.00 for rack mount.

* 4 lines per second printout * Takes 1-2-2-4 or 1-2-4-8 four line code * No stepping switches * Operates from only 3 volt input * Parallel entry * Special options available including 10 line and analog output * 6 digit printout, up to 12 digits on special order * Rugged unitized construction * Completely compatible with CMC's new solid state frequency-period counters, and other types of transistorized counting equipment.

For a demonstration of this remarkable new printer and complete technical information, call your nearby CMC engineering representative or write to us direct. Please address Dept. 553.

CMC

Computer-Measurements Company *A Division of Pacific Industries, Inc.*

12970 Bradley Avenue • Sylmar, California

Phone: EMpire 7-2161

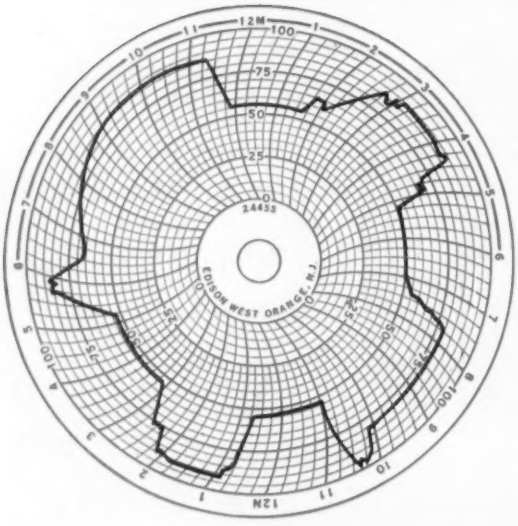
20A

CIRCLE 4 ON READER-SERVICE CARD

NEW FROM EDISON . . .

OMNICORDER

A PRECISE MINIATURE INKLESS RECORDER



- INEXPENSIVE
- RECORDS ANY VARIABLE
- REPLACES METERS OR INDICATORS
- PANEL OR BULKHEAD MOUNTED
- BUILT-IN VARIABLE CHART SPEED
- JUST 3¾″ x 3¾″ x 3″

Now you can take advantage of a new, economical means of recording any variable that can be converted to an electrical signal. Thanks to Omnicorder, you need no longer rely on meters or indicators, even where cost factors or space restrictions would ordinarily dictate the use of these instruments.

Measuring just 3¾″ x 3¾″ x 3″, Edison's Omnicorder, a unique circular chart recorder, is so compact that nine units occupy just one square foot of space. Thoroughly legible, yet requiring no ink, pen or ribbon, Omnicorder is equipped with a simple three-speed adjustment which regulates chart rotation, thereby providing time sequences to meet varied needs. A flick of the switch gives users a choice of these sequences: one hour, seven hours and thirty hours per revolution — or one day, seven days and thirty days per revolution.

Omnicorder's simple, inexpensive construction assures dependable operation and a long, maintenance-free life. Four types of meter movements are available to measure a wide range of AC and DC electrical quantities, ranging from thermocouple outputs to currents as high as 100 amperes. No amplification is ever required, even for signals as low as 10 microamps.

For complete information on this rugged, maintenance-free Omnicorder, write for Catalog 3057.

Stylus operates through this slot. The measuring system is sealed off from any careless tampering.

Zero Set Screw: Adjustment is made when measuring system is not printing and when the circuit to be recorded is disconnected.

Thomas A. Edison Industries
INSTRUMENT DIVISION
41 LAKESIDE AVENUE, WEST ORANGE, N. J.

CIRCLE 5 ON READER-SERVICE CARD

CIRCLE 6 ON READER-SERVICE CARD →

POST ELECTRONIC PRODUCTS and CONTROL SYSTEMS

ASSURE:

RELIABILITY • ACCURACY
LOW MAINTENANCE • PRODUCTION CONTROL

Post's *proven* electronic counters and control systems are in widespread use throughout industry. Serving such diverse needs as batch counting, measuring, sensing or machine control. Post electronic products are ideal production aids.

Note these examples of Post's broad line of Electronic Products . . .

COUNTERS

SD-1T Outmodes mechanical counters. Will operate at speeds up to 100 units per second. Single 'count' registers on visual totalizer as each 10th. item breaks beam. Note: 12 place tube available for counting dozens or gross lots.

P-5 Preset counting of any desired 'batch' — 1-100,000 units. Other models available for 10,000 or 1,000,000 range. Direct 'batch' readout on all models from totalizer . . . quantity less than 'batch' shown directly on tube face (s).

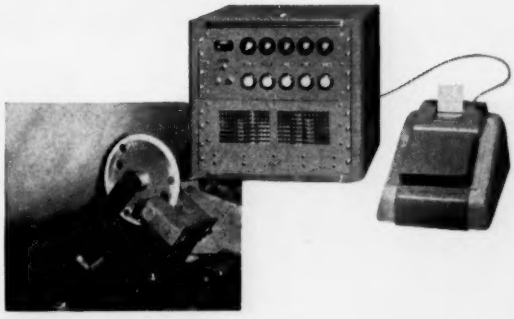
PW-5 PRESET Counter with BUILT-IN WARNING SYSTEM. Model shown will 'batch' count 1-100,000 units (inclusive) and warning selection dials may be set to energize a secondary control circuit, i.e., 'Batch' count desired 5000 . . . warning count desired 4900. When warning count reached, impulse may be given to flash light, operate solenoids for opening or closing feed gates, etc.

SENSING DEVICES

H-21-C A miniature, all purpose photohead. Ideal for limited space application. 'Head' not much longer than standard paper clip. Exciter lamp life 5000 hours. Utilizes photosensitive semi-conductor cell.

MH-2-P A new, compact magnetic switch in neat epoxy resin shell. . . . Magnetically operated as sensing device, the MH-2-P is capable of speeds up to 100 cycles per second — long life — no "bounce".

CONTROL SYSTEMS



LF-1A Lineal footage measurement, electronically . . . Capable of length measuring continuous production items, i.e., paper, wire, rope, ribbon, etc.
Features visual and printed readout.

**Representatives throughout the United States*
Request product literature today.

POST

ELECTRONIC PRODUCTS

Division of Reid Brothers Company, Inc.
12 LOTHROP STREET, BEVERLY, MASSACHUSETTS

Your special problems are earnestly requested!
Note: Complete line of production line counters available.

- SD-1T
- P-5
- PW-5
- H-21-C
- MH-2-P
- LF-1A

Please send me product literature on the following:

NAME _____

TITLE _____

COMPANY _____

ADDRESS _____

measure the volume of a pulse beat . . . the weight of a breath . . . the vacuum of outer space
measure gyro rotor unbalance . . . liquid level in a remote tank . . . the thickness of a continuous sheet of hot metal

Convert any variable into a change in capacitance and there's a Delta unit available to measure, record, or control that variable more accurately and more economically than was ever before possible.

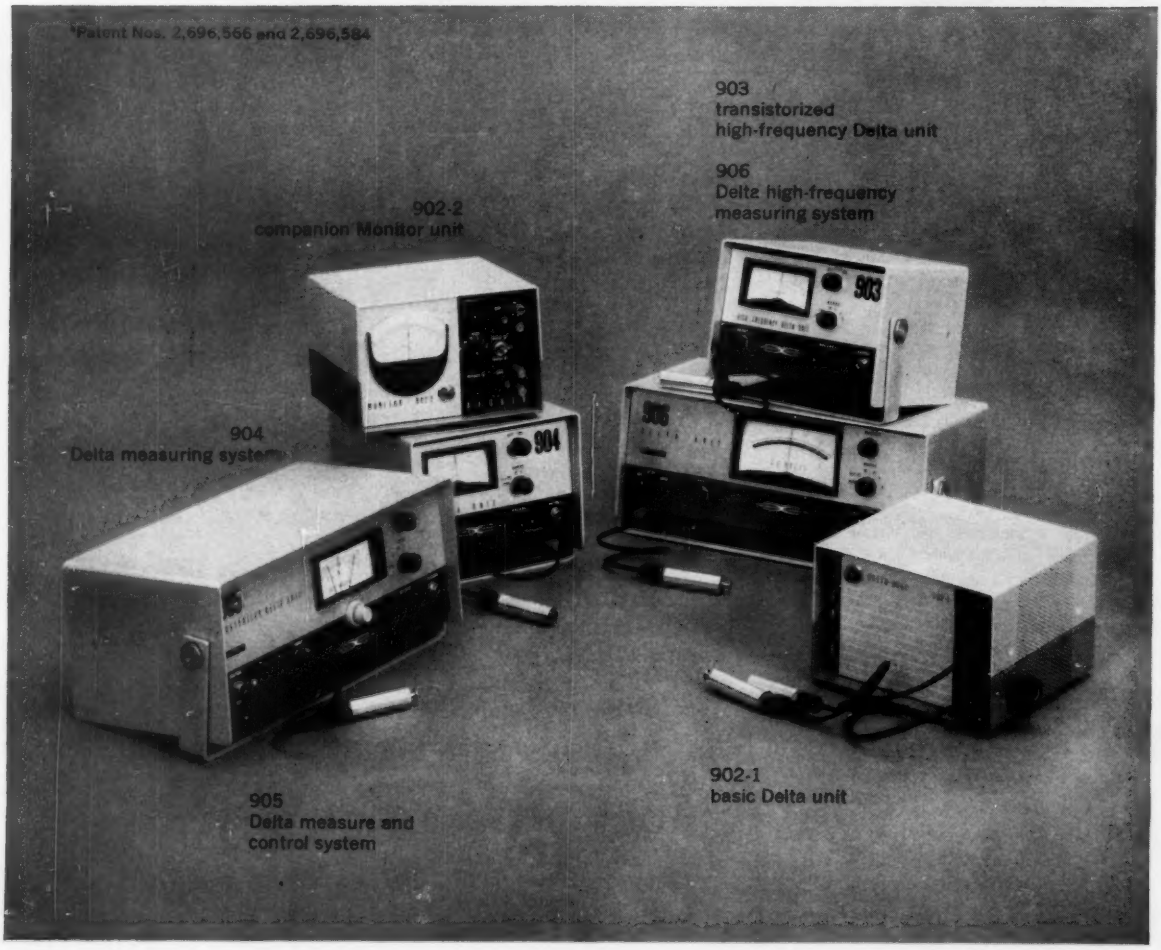
You just plug the Delta unit into a 115 Vac supply and hook up the probes to your simply constructed capacitance sensor. Capacitance changes as slight as 1% generate output voltages as large as 0.2 Vdc, indicating direction as well as magnitude.

Everything you need for measurement in the laboratory, on the bench, or in the field is built right into one or another instrument in the Delta family. All incorporate the proved principle of the Decker T-42 Ionization Transducer*, the most important advance in measurement in decades. All models but 902-1 have internal meters. Or, you can easily bypass the meter and feed results directly into external display, recording, or control equipment.

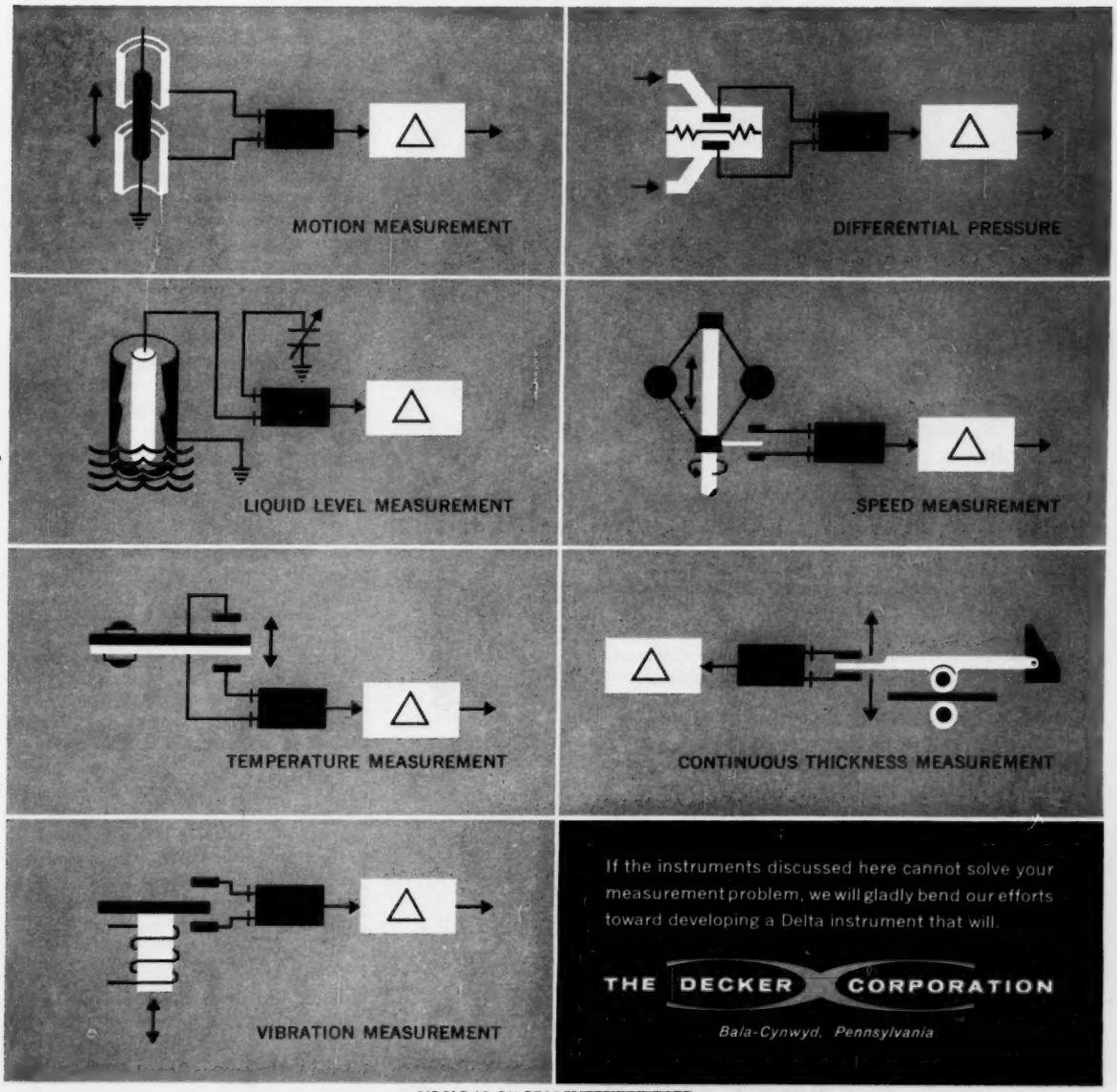
Write for complete details, specifications, and application suggestions in Series 900 Instrument Data Sheets, available without obligation. Or, just let us have your measurement problem, and we'll gladly recommend a practical solution.

THE DECKER CORPORATION *Bala-Cynwyd, Pennsylvania*

MEASURE ANYTHING!



DECKER'S DELTA UNIT makes non-contact capacitance gauging practical and economical for the first time. Compared with conventional capacitance measuring systems, the Delta unit has no complex circuitry, provides excellent long-term stability. The basic Delta unit is little more than a stable RF oscillator which excites the T-42 Ionization Transducer. The transducer output itself is a phase-sensitive differential d.c. voltage analogous to any change in capacitance across the probe terminals. Here are just a few of the uses to which Decker Delta units are daily put in research laboratories, manufacturing plants, defense installations, and hospitals.


MOTION MEASUREMENT
DIFFERENTIAL PRESSURE
LIQUID LEVEL MEASUREMENT
SPEED MEASUREMENT
TEMPERATURE MEASUREMENT
CONTINUOUS THICKNESS MEASUREMENT
VIBRATION MEASUREMENT
If the instruments discussed here cannot solve your measurement problem, we will gladly bend our efforts toward developing a Delta instrument that will.
THE DECKER CORPORATION
Bala-Cynwyd, Pennsylvania

CIRCLE 35 ON READER-SERVICE CARD

Now, in Strain Gage Pressure Transducer Applications...

THROW AWAY YOUR AMPLIFIER!

The Fairchild 3S-G is the industry's first commercially-available line of solid-state strain gage pressure transducers that produce a 5-volt d-c output signal!

This revolutionary new line of precision instruments offers improvement on the desirable characteristics of conventional strain gage pressure transducers, piezo-electric pressure transducers and potentiometer-type pressure transducers.

The 3S-G is small (approx. 3 inches long) and lightweight (approx. 5 ounces) and does not require external amplification.

3S-G pressure transducers are rugged. They are responsive to both static and high-frequency dynamic inputs. They possess extraordinary environmental capabilities, and are extremely accurate. They produce a high-output signal and are completely solid-state which assures the ultimate in reliability. The 3S-G with all these features, is also competitively priced.

TRIPLE S-G
SOLID STATE STRAIN GAGE TRANSDUCER

FAIRCHILD CONTROLS CORPORATION

A Subsidiary of Fairchild Camera and Instrument Corporation

3S-G pressure transducers are available in new and versatile performance variations — for military and industrial applications. Write for new catalog.

225 Park Avenue, Hicksville, L. I., N. Y. 6111 E. Washington Blvd., Los Angeles, Calif.

TRANSDUCERS • RATE GYROS • POTENTIOMETERS • ACCELEROMETERS

CIRCLE 123 ON READER-SERVICE CARD

I&CS LETTERS TO THE EDITOR

Editor, I&CS:

From your August 1960 "Problems in Instrumentation," there are two particular applications in which we are interested and would appreciate further information. Under the section entitled *Analytical*, the third and eighth items appear to involve color determination. As such, I would appreciate it if you would forward information on our colorimetry and corporate activities to the particular people that were concerned with those instrumentation problems. Item 3 had to do with chemical and physical analysis and specified that color was part of the application, in tetraethyl load production. Item 8 concerned the processing of pineapple and required the measurement of color, pH and brix. Since at the present moment we are attempting to evaluate potential applications for color determination and, additionally, seek to develop specific instrumentation control systems for color applications, we would very much like to get in touch with the organizations having the above problems.

Alfred R. Seville
Manager—Colorimetry
Allied Research Associates, Inc.
Boston 15, Mass.

This letter will inform the men with the problems.

Editor, I&CS:

I am sorry that my first letter to you concerning your fine magazine should be one of criticism. However, I would like to take exception to some of the remarks in the Editorial by Mr. D. J. Kipp, as it appeared in the January 1961 issue:

1. Judging from the frequent usage of the words "respect" and "prestige" in articles about Professional Engineering by Professional Engineers, the lack of same must be quite a sore point with these people. It seems to me that a true professional might be content with the earned respect from his coworkers and, where merited, with recognition from his professional Society, be it the ASME, AIEE, etc.

2. Just why the title "engineer" should be devoted exclusively to a small clique of people who at one time or another have managed to pass one particular exam, is beyond my

ken. What guarantee is there that once a man "earns" the magic title by passing such an exam, he will ever open another engineering text? And who among us is to be the all-knowing god able to determine the extent of a man's professional abilities from his answers to ten or twenty questions? And if Mr. Kipp deems his group more suitably qualified to judge an Engineering Ph D than the University that granted the degree, might not those same people view Mr. Kipp and his fellows with just a trace of contempt?

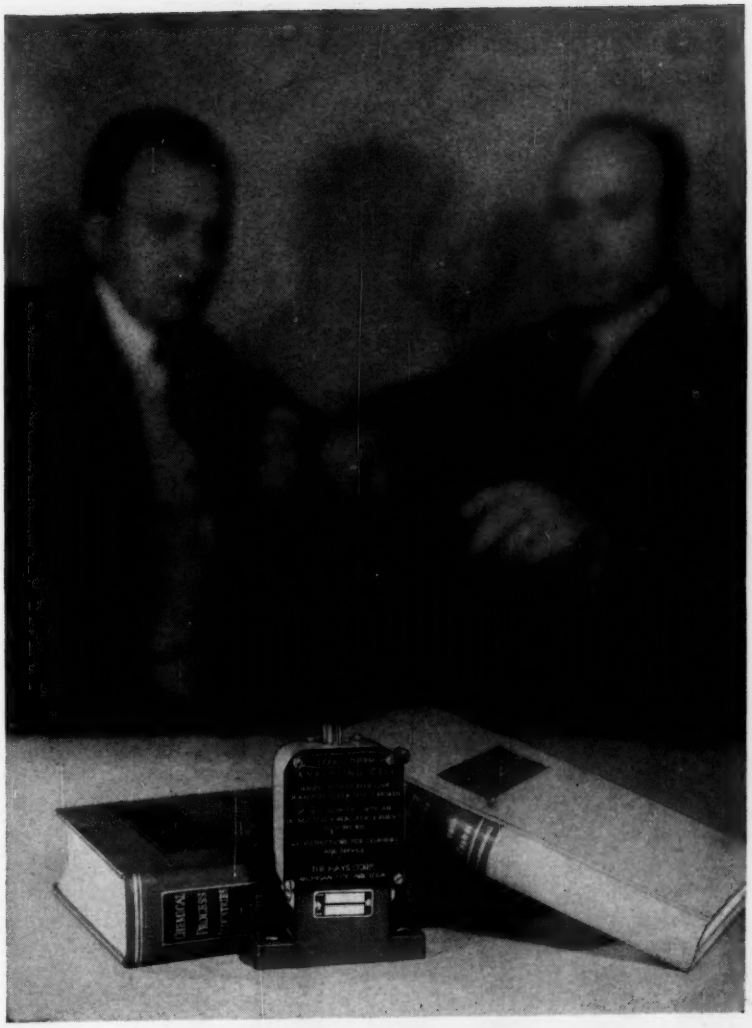
3. The bland confidence that all advocates of the P.E. licensing system have in those that possess the magic title is ludicrous. No title yet concocted can assure the public complete protection from purchasing improperly engineered equipment or installations. Does he wish us to believe that the lawfully titled professionals never "goof"? His sixth paragraph so states.

4. Again, Mr. Kipp's approach to further education for the engineer "hungry" for advancement in the new developments is one of "let management provide it for us." It seems to me a more mature and even a more "professional" attitude would be "I think I'll take a few night courses on my OWN!"

5. Three of the four conclusions drawn by Mr. Kipp are not proved by the text of his article. Can he produce figures proving that licensed engineers produce more work per hour than unlicensed ones? Can he prove that merely calling a man an engineer will increase his output? I think not, or we would all have company-bestowed "chief engineer" titles. As for the staff a true professional must demand: isn't it true that a considerable and significant part of every job lies in the engineering of the "details"? If we are required by the rules of Mr. Kipp's organization to turn these over to mere designers and draftsmen, what will be left for the engineer but to sit and "think big"?

In conclusion, I would like to state that I believe, but cannot prove, that the engineers who hunger for a higher level of respect, and who would do anything to keep their sons from entering the field, are in a distinct minority. There is a considerable number of us "non-registered" engineers who find the work exciting and quite worthwhile, as well as a means to earn an adequate living.

Joseph L. Grannen, EE
Vacaville, California



"continuous analysis of almost any gas?"

"Yep . . . at a fifth the cost of a Chromatograph"

That's the analyzing cell of the standard Hays Thermal Conductivity Analyzer, proven in over ten years of successful experience with many gases. This Analyzer is rugged, dependable . . . gives a continuous record, not just periodic samplings. With the Hays Universal Recorder . . . and one of the wide selection of Hays sampling systems tailor-made for your application . . . it solves almost any gas analysis problem.

for further details write for bulletin B641

THE hays CORPORATION • MICHIGAN CITY, INDIANA

CIRCLE 10 ON READER-SERVICE CARD

"DIMENSIONLESS"
INDUSTRIAL TRANSDUCER
for gage, absolute and differential pressure measurement

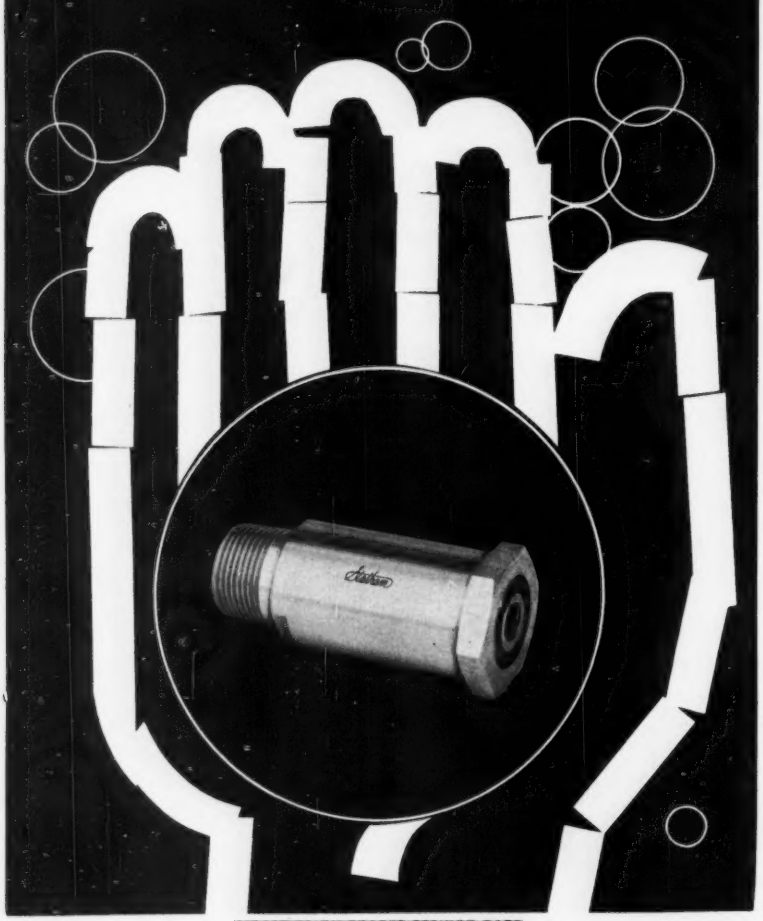
The P713's unique "Dimensionless" principle eliminates many of the critical aspects of finite distances and dimensional stability in conventional gage configurations. For the first time, it offers industry a high performance electrical transmitter for control, data logging and computer systems.

"Dimensionless" principle is described in a free 28-page booklet, "Transducers for Industrial Instrumentation."

Statham
Instruments, Inc.
12401 W. Olympic Blvd.
Los Angeles 64, Calif.
GRanite 8-0361/TWX:
West Los Angeles CAL 6602

Check these features of the P713:

- Outstanding performance in temperature stability and long term zero drift
- Infinite resolution
- Insensitivity to vibration and shock
- Compact size
- High accuracy calibration accomplished electrically at the control room
- Ultimate in ruggedness, simplicity and reliability



CIRCLE 11 ON READER-SERVICE CARD

Editor, I&CS:

This (The Engineering Shortage by Kipp, Jan. *ICS*) is too much to swallow without disapproval. It is a poor excuse for an editorial. I don't believe Mr. Kipp himself believes what he has said.

If any reader or subscriber of *Instruments and Control Systems* is not an engineer, he is sure to become angry when he reads this.

In 1940, major oil companies were paying Petroleum Engineers $150 a month. Salaries are still too low today, I agree . . . But Kipp has implied that engineers are "due" same gratuity from the rest of civilization because they exist. He'll get prestige and income when he earns them.

William Linville
Leslie Brooks & Associates, Inc.

Editor, I&CS:

We want to commend you on the very excellent editorial by Mr. D. J. Kipp, P.E., entitled "The Engineering Shortage" that appeared in your January 1961 issue. We agree 100 per cent with the thoughts and ideas presented for we have been thinking and talking for years about this type promotion which is direly needed to strengthen the engineering profession to the level it should be. We are sure all "engineers" (used in the sense Mr. Kipp suggests) will agree with this editorial, for in our opinion the profession anxiously seeks a formula to kindle a promotional fire to put the profession at the status it deserves.

W. B. Crene, P.E.
Riegel Textile Corporation
Conover, N. C.

Editor, I&CS:

Your publication is without doubt the finest in the instrument field, but I'm tired of being reminded each year that my subscription is to expire. Therefore, please find enclosed check for a five-year subscription.

How about considering a series on nuclear instrumentation? This area is relatively new but will be of vital interest in the future.

W. F. MacDonald
Convair Astronautics
San Diego, Calif.

A series on this subject appeared in I&CS in the April, 1958 issue. An earlier series culminated in the book *Nuclear Reactors for Industry and Universities*, edited by E. H. Wakefield, now available from us at $2.00. More in the subject is planned for next year.

READER INQUIRIES

Cherry Inspection

Secretary of fruit canning company would like to find or develop machine or method of inspecting cherries to assure removal of pits, and to count quantity of cherries in heavy sugar syrup A-6114

Hydraulic Oil Flow

Manufacturer's representative is interested in sources of supply for positive displacement meters to measure hydraulic oil flow in the range of 0-50 gpm, @ 0-3500 psig, and 30-350°F. Must be suitable for portable use. A-6113

Random Noise Generators Storage-delay Memory Components

Engineer would like to find suppliers of above items for use in simulation and statistical analysis. A-6112

Sensitive Pressure Gage

Geologist would like to find (or design) a pressure gage with an extremely small displacement volume, possibly based on the transducer principle. Changes in volume and pressure of a mercury cell of ten cu-cm volume are needed (in increments of 0.00025 cu cm, and a pressure range of one to 10,000 psi. Critical pressure range is from 10 to 1000 psi). A-6111

Light Lumen Meters

Engineer seeks light lumen meters covering light and possibly frequency (as color is being used). A-6115

Books:

Electronic Circuitry for Instruments and Equipment

by M. H. Aronson. "Comprehensive source book on instrument circuitry" this complete home-study text includes 458 multiple-choice questions (and answers). 215 illustrations, 10 tables, comprehensive index. Paperbound, 324 pages, 1957 (revised edition). **$2.00**

100 Electronic Circuits

by M. H. Aronson and C. F. Kezer . . . covers amplifiers, oscillators, pulse circuits, phase shifters, etc. Complete with all circuit component values and response specifications. Paper, 180 pages, 1957.

Vol. 1 ..... $2.00
Vol. 2 ..... $2.00

INSTRUMENTS PUBLISHING CO.
845 RIDGE AVENUE
PITTSBURGH 12, PENNA.

Chromel*-Alumel
THERMOCOUPLE ALLOYS

a complete family of time-tested materials developed especially to meet your particular application requirements

Remarkable alloys, Chromel and Alumel—in many more ways than one. For although they were discovered over 50 years ago, they're still new today. As new as the newest need for accurate temperature measurement—still the only base metal thermocouple alloys known that have proved their reliability over the entire range of temperatures from —300° up to +2300°F. What's more, in addition to the original standard materials guaranteed to register true temperature-emf values within ±4°F. from −300° up to +530°F. and within ±0.75% from +531°F. up to maximum recommended operating temperature, they are now available in the following special grades to meet the exacting requirements of your particular applications:

Specification 3G-345
A special grade of Chromel wire developed expressly for use in reducing or corrosive environments—with temperatures in the critical operating range between 1600° and 1900°F.

Specification 3G-196
A special grade of Alumel wire possessing outstanding resistance to oxidation at high temperatures. Developed especially for use in such atmosphere applications operating above 1600°F.

Specification 3G-115
Chromel and Alumel thermocouple grade material of guaranteed emf that is specially processed to close resistance limits. Typical uses include measuring exhaust temperatures of jet aircraft engines.

Specification 3G-170
Specially processed Chromel and Alumel thermocouple grade wires matched to closer than standard emf tolerances for applications requiring accuracy within ±5°F. at temperatures above 1000°F.

Specification 3G-178
Special research grade Chromel and Alumel thermocouple wires for precision laboratory work. Accuracy is guaranteed within ±2°F. from −300° up to +530°F., and ± ¾% from 531° to 2300°F.

Specification 3G-187
A special grade of Chromel and Alumel thermocouple wire developed for use in nuclear reactor applications. Has good stability of emf during long time exposure at temperatures up to 1000°F.

Specification 3G-161
Guaranteed millivoltage Chromel and Alumel thermocouple grade wire specially processed to provide a smooth, bright, semi-hard material properly tempered for cold-heading operations.

Specification 3G-213
Guaranteed millivoltage Chromel and Alumel thermocouple grade alloys supplied in the form of hot rolled rod and cold drawn wire specially processed to obtain proper temper for machining.

Specification 3G-220
A special grade of Chromel and Alumel wire processed for use in sheathed thermocouple units. Available with emf guaranteed to within standard tolerances and also to ½ standard limits.

Complete New Catalog-Manual contains detailed information on the entire family of Chromel-Alumel thermocouple grade alloys—plus much helpful technical application data. Write for your copy today!

**The words "Chromel" and "Alumel" are registered trademarks of*

HOSKINS MANUFACTURING COMPANY
4445 Lawton Avenue • Detroit 8, Michigan

In Canada: Hoskins Alloys of Canada, Ltd., Toronto, Ontario

Producers of Custom-Quality Resistance, Resistor and Thermoelectric Alloys Since 1908

CIRCLE 12 ON READER-SERVICE CARD

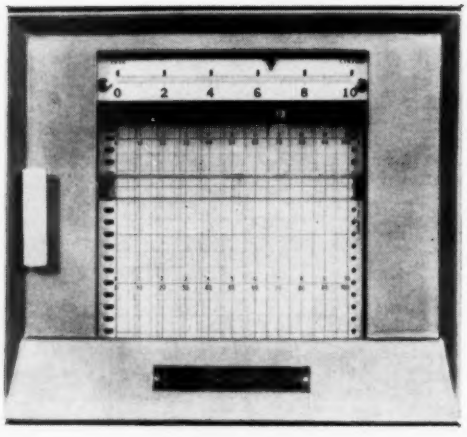
if PANEL SPACE or PORTABILITY is your problem...

The Westronics Miniature MULTIPOINT Recorder Model M5A is your perfect solution.

The panel space occupied by the Westronics Miniature MULTIPOINT Recorder is only 8½ x 9⅝ inches, or only 25% of the panel space required by most large case recorders.

The Westronics Miniature MULTIPOINT Recorder scans and measures 2 to 12 different input sources at the rate of 5 seconds per point.

Westronics manufactures a complete line of miniature and full size recorders with more optional features than any other manufacturer.

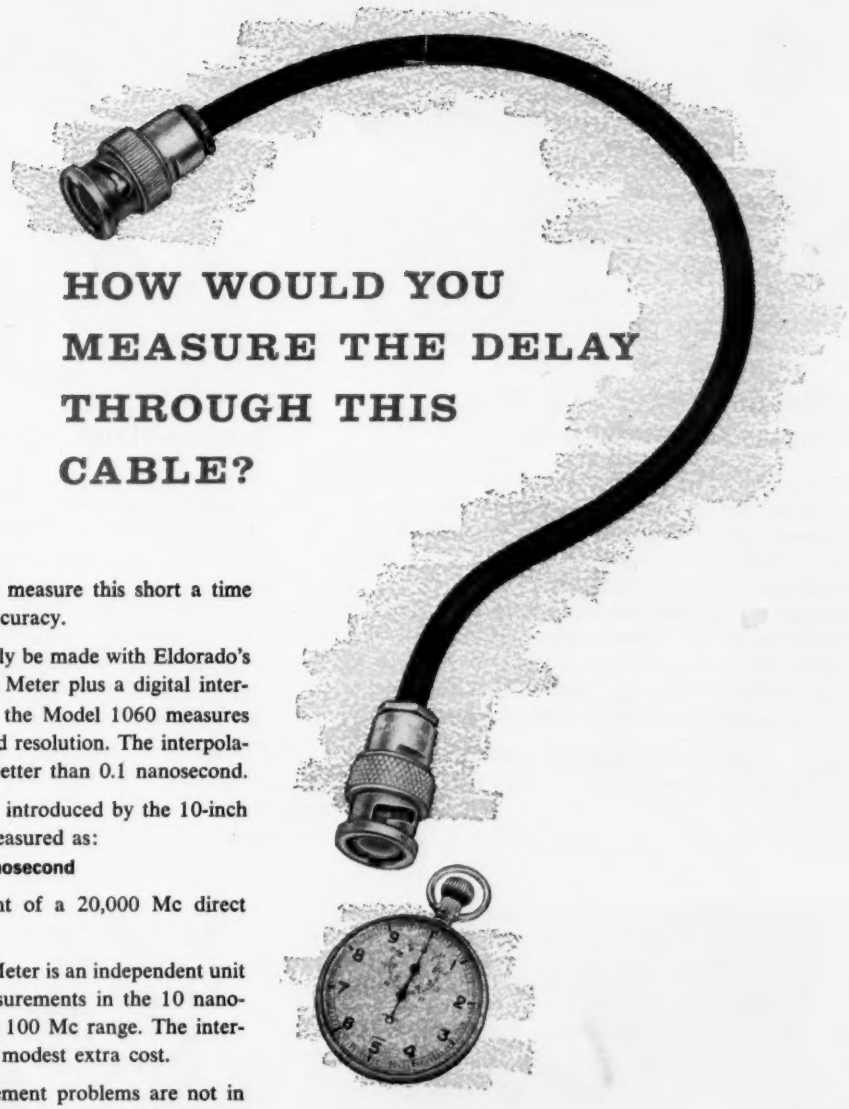


STANDARD UNITS AVAILABLE FROM STOCK. SPECIFICATIONS UPON REQUEST.

wi westronics, inc.

TWX FT 8248 U • 3605 McCART STREET • FORT WORTH, TEXAS

CIRCLE 13 ON READER-SERVICE CARD



HOW WOULD YOU MEASURE THE DELAY THROUGH THIS CABLE?

Until now it was impossible to measure this short a time interval with sub-nanosecond accuracy.

Now, this measurement can easily be made with Eldorado's new Model 1060 Time Interval Meter plus a digital interpolator. Solid state throughout, the Model 1060 measures time interval with 10 nanosecond resolution. The interpolator improves the resolution to better than 0.1 nanosecond.

Using this equipment, the delay introduced by the 10-inch cable plus its connectors was measured as:

1.43 ±.05 nanosecond

This resolution is the equivalent of a 20,000 Mc direct counting time interval meter!

The Model 1060 Time Interval Meter is an independent unit suited for all time interval measurements in the 10 nanosecond range or counting in the 100 Mc range. The interpolator accessory is available at modest extra cost.

Even though your time measurement problems are not in the area of cable delays, but rather in the fields of radar ranging and calibration, high speed velocity measurement, rocket sled timing, shock waves, ultra-high speed photography, satellite tracking, ballistic missile studies, or any field where data is gathered in the form of a time interval measurement, this new technique may offer the solution you have been seeking.

For specific details on the Model 1060 and the interpolator, and for assistance in applying them to *your* problems, contact your Eldorado engineering representative or drop us a line at the factory. Please address Dept. 54.

BASIC DATA MODEL 1060 COUNTER-TIME INTERVAL METER

Time Interval Meter

MAX. TIME INTERVAL: 10 seconds • RESOLUTION: 10 nanoseconds
TYPICAL START/STOP PULSE REQUIREMENT: −4 volts into 50 ohms
OSCILLATOR STABILITY: 0.0001% • READOUT: Nixie inline and output for printout.

Counter

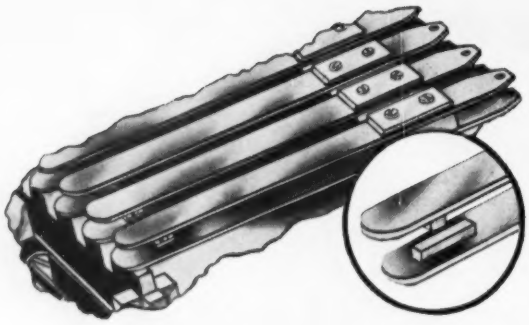
STORAGE: 10^9 counts • MAX. COUNTING RATE: 100 Mc/s
TYPICAL INPUT PULSE REQUIREMENT: +4 volts into 50 ohms
DELIVERY: 45 days.

Eldorado Electronics

2821 TENTH STREET
BERKELEY 10, CALIFORNIA
PHONE: THORNWALL 1-4613

21

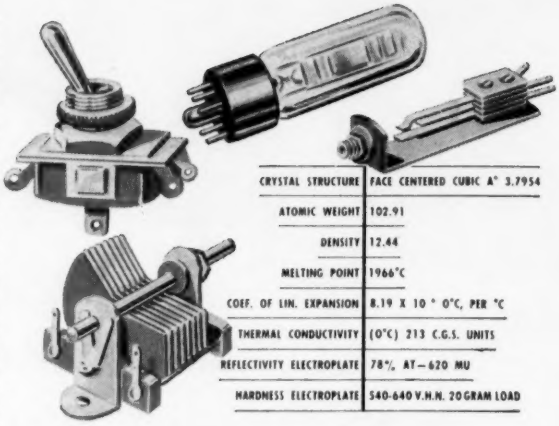
CIRCLE 14 ON READER-SERVICE CARD



ECONOTAPE CONTACTS ARE MOST EFFICIENT FOR ELECTRICAL RELAYS

High reliability welded contacts and contact assemblies available for your relays. Weld strength guaranteed. • Overall contact height held within ±.00025. Assemblies are available in gold, platinum, palladium, silver and their various alloys—both solid and laminated. Single contact usable for various contact ratings, for wet and dry circuitry—assemblies protected for shelf life and handling. Designs for attachment to header by welding or brazing. Complete electrical and mechanical design services available.

D. E. MAKEPEACE DIVISION
PINE & DUNHAM STREET • ATTLEBORO, MASS.



CRYSTAL STRUCTURE	FACE CENTERED CUBIC A° 3.7954
ATOMIC WEIGHT	102.91
DENSITY	12.44
MELTING POINT	1966°C
COEF. OF LIN. EXPANSION	8.19 X 10 ° 0°C, PER °C
THERMAL CONDUCTIVITY	(0°C) 213 C.G.S. UNITS
REFLECTIVITY ELECTROPLATE	78% AT—620 MU
HARDNESS ELECTROPLATE	540-640 V.H.N. 20 GRAM LOAD

RHODIUM PLATING RESISTS CORROSION

Rhodium plating offers outstanding protection against surface corrosion under all atmospheric conditions. Used in electrical and electronic applications, it improves efficiency whenever a low-resistance, long-wearing, oxide-free component is required . . . assures low noise level for moving components . . . provides positive action for components subject to long periods of inactivity . . . eliminates partial rectification and unwanted signals by keeping components oxide-free. Send for complete technical data.

CHEMICAL DIVISION
113 ASTOR STREET • NEWARK, N. J.

FINE WIRE FOR EVERY APPLICATION

A thoroughly dependable source for fine wire of ductile and non-ductile materials for every application. Special processes have been developed for bare drawing wire as fine as .0004". Wollaston Process for ductile metals . . . Taylor and extrusion methods for non- ductile metals are employed to meet requirements for finer wire. All standard fine wires are stocked for prompt delivery. Full facilities are available for production of fine wire made to customer's individual requirements. Write for details.

BAKER PLATINUM DIVISION
113 ASTOR STREET • NEWARK, N. J.
FOR CONTACTS—CIRCLE 15 ON READER-SERVICE CARD
FOR RHODIUM PLATING—CIRCLE 16 ON READER-SERVICE CARD

SIMPLIFIED SILVER PLATING FOR ELECTRICAL AND ELECTRONIC COMPONENTS

The simplest, most efficient process for protecting electrical, electronic and lamp components with mirror-bright silver plating in flash to heavy deposits. Silva-Brite is a crystal-clear solution—work is visible during plating process. Plating is quick, easy, non-critical with results assured at current densities from 10 to 40 amps psf—and little or no polishing required. Normal room temperature operation minimizes fumes and bath decomposition. Write for complete information on Silva-Brite and application procedure.

AMERICAN PLATINUM & SILVER DIVISION
231 N. J. RAILROAD AVENUE • NEWARK, N. J.
FOR FINE WIRE—CIRCLE 17 ON READER-SERVICE CARD
FOR SILVER PLATING—CIRCLE 18 ON READER-SERVICE CARD

PLATINUM SPIRALS MEASURE TEMPERATURE BY ELECTRICAL RESISTANCE CHANGE

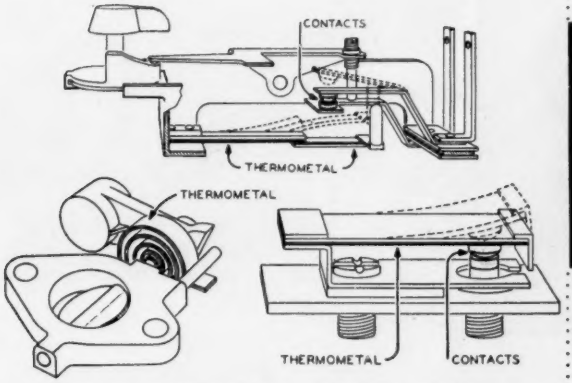
Precise electrical thermometer using platinum spirals provides temperature measurements within ± 1/10th of 1°C. Voltage signal varies with temperature for covering a range from −220°C to +500°C. The temperature transistor elements, sealed in hard glass thin wall tubes, provide fast time response. 25, 50 or 100 ohm units available as well as a selection of tube geometries. A similar group of platinum spirals are ceramic encased for measuring temperatures as high as 750°C with slightly less accuracy. Special laboratory standard precision electrical thermometers also available.

INDUSTRIAL EQUIPMENT DIVISION
INSTRUMENTS AND SYSTEMS SECTION
850 PASSAIC AVENUE • E. NEWARK, N. J.

IMMERSION GOLD COATING FOR ELECTRICAL AND ELECTRONIC PARTS

Use Atomex gold immersion solution for more permanent, less expensive coating of printed circuits, metallized plastics, etc. with complete assurance of tarnish resistance and electrical resistivity. In a simplified immersion process, 24K gold is deposited by ionic displacement in a thin, dense, uniform protective layer. • Atomex is the first practical gold immersion solution containing no free cyanide. It eliminates need for costly analytical controls. Write for technical data.

CHEMICAL DIVISION
113 ASTOR STREET • NEWARK, N. J.



CONTROL TEMPERATURE, CURRENT AND VOLTAGE WITH THERMOMETAL®

Leading manufacturers rely on the dependable performance of Wilco Thermometal in electrical appliances, thermal cutouts, heating controls and many other applications involving the indication and accurate control of temperatures, electrical currents, voltages, etc. Thermometal is supplied in strip form, rolled and slit to close tolerances and tempered to specification. Thermometal elements and sub-assemblies are also supplied to specifications, with or without contacts attached. Send for literature.

H. A. WILSON DIVISION
U.S. HIGHWAY 22 • UNION, N. J.

FOR PLATINUM SPIRALS—CIRCLE 19 ON READER-SERVICE CARD
FOR THERMOMETAL—CIRCLE 20 ON READER-SERVICE CARD

ENGELHARD

INDUSTRIES, INC.

EXECUTIVE OFFICES:
113 ASTOR STREET • NEWARK 2 NEW JERSEY

SALES OFFICES: CHICAGO • DALLAS • DETROIT • HOUSTON • LOS ANGELES • NEW YORK • ORLANDO • PROVIDENCE • SAN FRANCISCO • WASHINGTON, D. C.

Please send literature as indicated below, addressed to my attention:

☐ Econotape ☐ Rhodium Plating

☐ Fine Wire ☐ SilvaBrite Silver Plating

☐ Platinum Spirals ☐ Atomex

☐ Thermometal

NAME.....

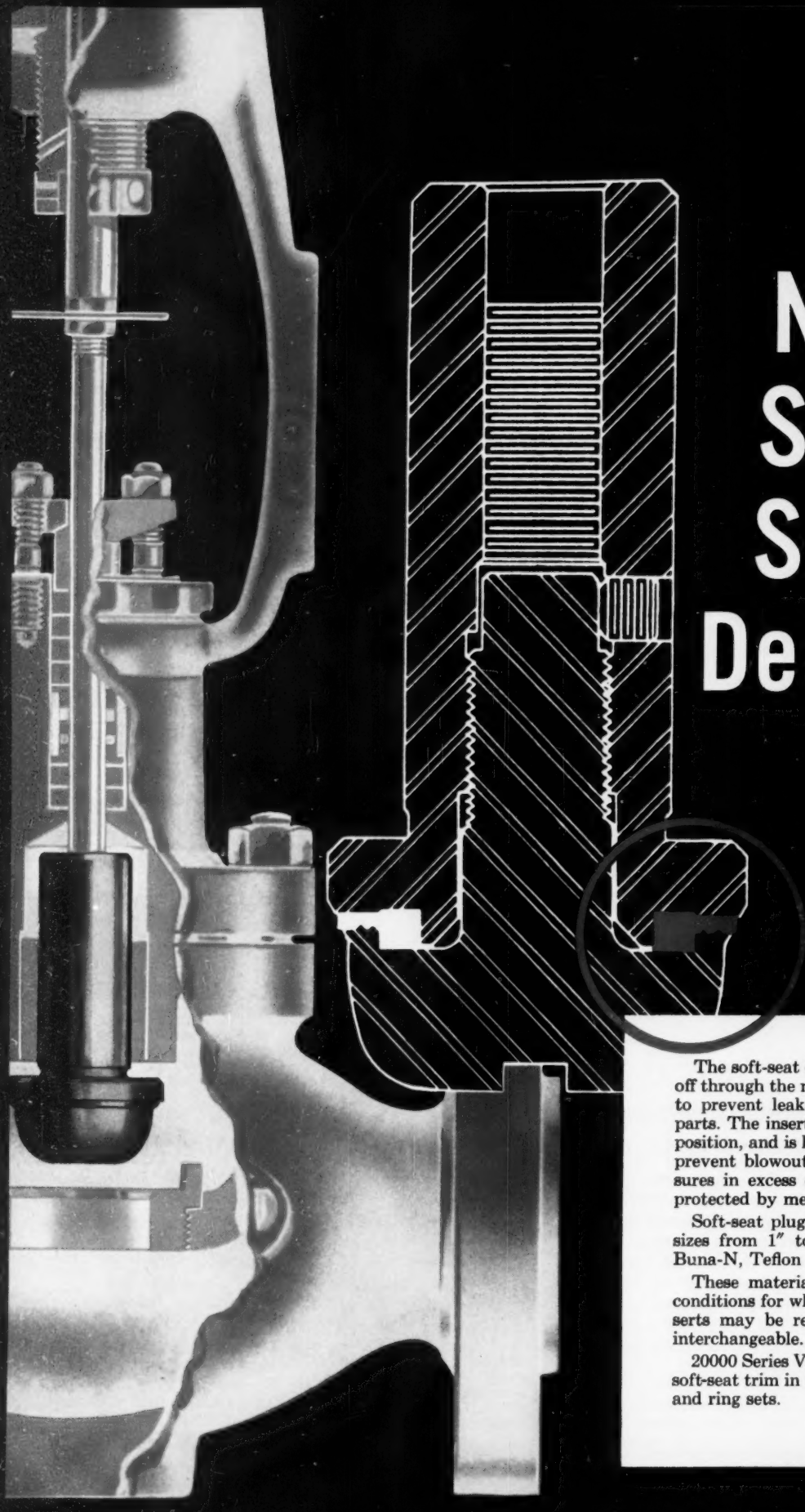
TITLE.....

FIRM.....

STREET.....

CITY..... ZONE..... STATE.....

FOR GOLD COATING—CIRCLE 21 ON READER-SERVICE CARD



New Soft-Seat Design...

The soft-seat design provides tight shut-off through the normal flow path and a seal to prevent leakage through the threaded parts. The insert is fully retained in closed position, and is held with sufficient force to prevent blowout even at differential pressures in excess of 1000 psi. The insert is protected by metal-to-metal backup.

Soft-seat plugs are available in nominal sizes from 1″ to 10″. Inserts may be of Buna-N, Teflon or Glass Filled Teflon.

These materials are long lasting under conditions for which they are designed. Inserts may be replaced and materials are interchangeable.

20000 Series Valves may be converted to soft-seat trim in the field by installing plug and ring sets.

NOW!

The Advantages of 20000 Series Valves plus

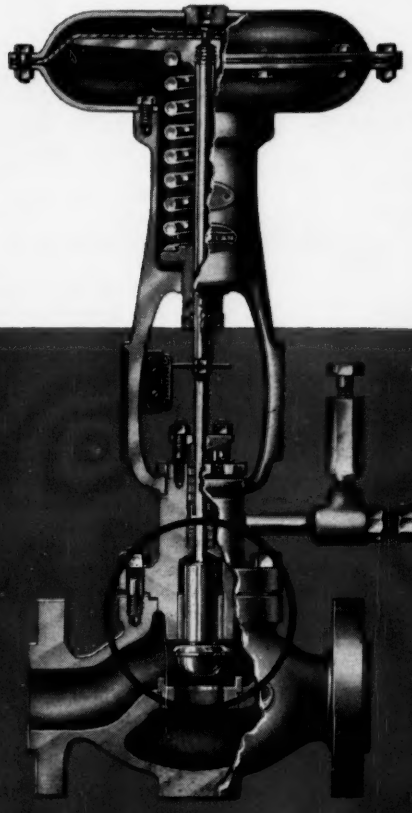
TIGHT SHUTOFF

without Sacrificing Capacity or Characteristics

Now you can have high-capacity single-seated control valves with soft-seat tightness — without sacrifice of percentage characteristics. This design, moreover, permits static pressures and pressure drops up to 500 psi.

Soft-seat inserts of several materials are available to meet varying conditions. For example: *Buna-N* for temperatures to 200 F; *Teflon* for temperatures to 300 F and resistance to chemicals; *Glass Filled Teflon* for temperatures to 500 F, for high-mechanical strength, corrosion resistance and for steam service. Metals available are identical with those normally used in metal-to-metal seating.

This new trim is a logical extension of the versatility inherent in the 20000 Series, designed to meet the growing preference for single-seated control valves. If you do not yet have information on the most versatile control valves available, ask a Mason-Neilan representative or write —



MASONEILAN

Products that work for your profit

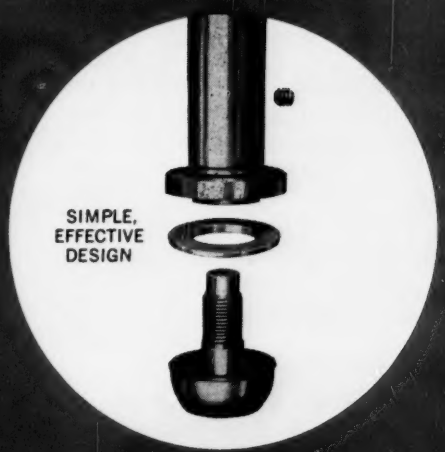
MASON-NEILAN

Division of Worthington Corporation

55 NAHATAN STREET, NORWOOD, MASS., U.S.A.

Sales Offices or Distributors in Principal Cities in United States and Abroad

In Canada: Worthington (Canada) Ltd., Mason-Neilan Division



THIRD EXPANSION IN 15 YEARS

MASSA
A DIVISION OF
COHU
ELECTRONICS, INC.

The MASSA DIVISION of Cohu Electronics, Inc., is a pioneer in the field of electroacoustics, and its contribution to the basic science of acoustics and research accomplishments has established many fundamental concepts upon which this important industry has advanced.

As a result of its diversified electronic developments, the company has just completed its third expansion since its establishment in 1945.

Through contract and proprietary efforts, the company is deeply engaged in the design and production of electronic detection equipment required as a pivotal part of the Nation's Anti-Submarine activities.

MASSA DIVISION is interested in the future, and as the new expansion program progresses, there will be many excellent opportunities for qualified men who are invited to forward their confidential inquiries to the personnel director.

precision in electroacoustics

- Accelerometers
- Microphones
- Recording Systems
- Hydrophones
- Sonar Transducers

RECORDERS — The complete line of Massa multichannel and portable High-Speed Rectilinear ink writing Recording Systems, is highly regarded in an exceptionally large and competitive market.

UNDERWATER SOUND — In addition to its basic SONAR contributions to the U. S. Navy, Massa Hydrophones are used as reference standards by military and industrial organizations engaged in Sonar research and manufacture.

VIBRATION & SOUND PRESSURE — Massa has developed a wide line of precision acceleration (Accelerometers), Sound Pressure (Microphones) measuring systems. These instruments find wide application in ground and airborne missiles, space and aircraft projects.

At I.R.E. Visit Booth #3603 — 3605

MASSA DIVISION

COHU ELECTRONICS, INC. HINGHAM, MASS.

CIRCLE 23 ON READER-SERVICE CARD

ICS BOOKS

Reciprocals of the Integers from 1000 to 9999, by T. H. Redding [c1960] Taylor & Francis Ltd., Red Lion Court, Fleet St., London, E.C.4, England, 42 pp., 10″, clothbound, 18s. 6d. Tables list the 10^6 multiples of the reciprocals correct to the third place of decimals, arranged for use with mechanical calculating machines to facilitate evaluation of quotients and compound fractions. Appendix describes mechanical barrel-setting calculators.

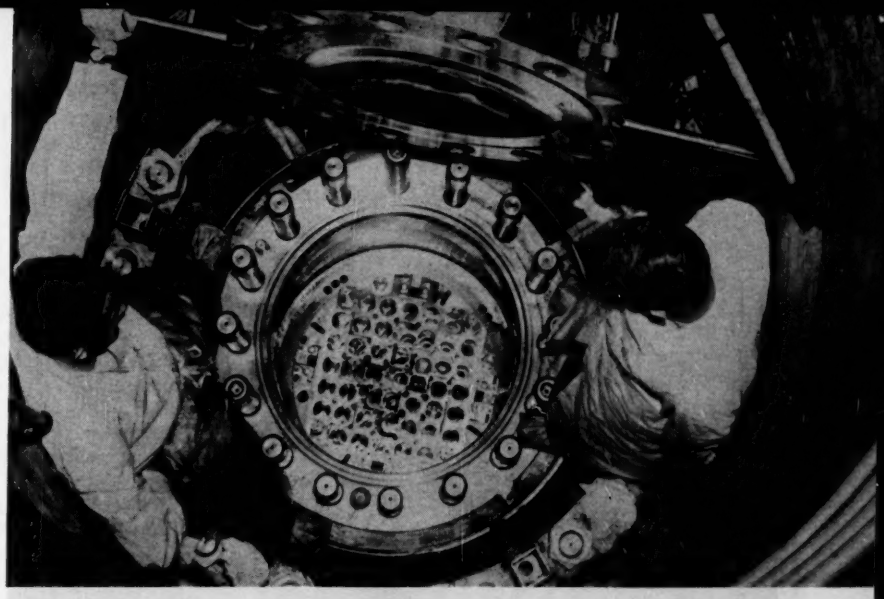
Solar Cell and Photocell Handbook, by John Sasuga, [c1960] International Rectifier Corp., 112 pp. 9″, paperbound, $2.00. Handbook contains over 75 practical light-operated circuits, projects and demonstrations of both selenium photocells and silicon solar cells. Included are chapters on basic photovoltaic theory, radiation theory, performance characteristics, and infrared and ultraviolet photocell applications.

Theory of Inertial Guidance, by Connie L. McClure, [c1960] Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N. Y., 340 pp., 9″, clothbound, $12.00. This book combines in one volume the classical concepts of Newtonian dynamics and motion with the latest topics relating to schematic design, error analysis, and functional appraisal. Presupposes an undergraduate background in math and elementary mechanics.

Transformers and Generators for Power Systems, by R. Langlois-Berthlot [c1960], Philosophical Library, Inc., 15 East 40th St., New York 16, N. Y., 541 pp., 8½″, clothbound, $12.00. Written for student and engineer, text is divided into two parts, one dealing with transformers, the other one with the synchronous machine. Contains a complete survey of articles referring to the subject that have appeared in British, American, and French engineering journals.

Industrial Electronics and Control, by Royce Gerald Kloeffler, second, revised edition, [c1959, 1960] John Wiley & Sons, 440 Fourth Ave., New York 16, N. Y., 540 pp., 9″, clothbound, $10.00. Revised to approach the electronic theory of rectification, amplification, and oscillation through solid-state concept. Written in simple style for self tuition.

CIRCLE 24 ON READER-SERVICE CARD →



***These CEC transducers measure pressures in rugged* HIGH TEMPERATURE AND NUCLEAR ENVIRONMENTS**

Here are the two best high temperature pressure measurement instruments in their range: CEC's 4-316 and 4-317 Strain Gage Pressure Transducers.

They operate continuously and accurately at temperatures to 600°F. in a variety of applications—from engine and structural testing for the aircraft and missile industry to use in the high radiation environment of nuclear reactor cores (*see photo above*). In cryogenic laboratory applications, they are operable down to 1/10 of a degree Kelvin.

***Low Pressure Type 4-316* more than doubles the temperature range of ordinary pressure transducers... can actually withstand 650°F. It is available in gage or uni-directional differential models in pressure ranges of 0-15, 25, 50, 100 and 150 psig or psid. In bi-directional differential models, the 4-316 is operable in pressure ranges of ±7.5, ±12.5 and ±25 psid. *Bulletin CEC 4316-X3*.**

***High Pressure Type 4-317* measures gage pressures of from 100 to 5000 psi at 600°F. A special cooling adapter used with the instrument extends its range to 2000°F. *Bulletin CEC 4317-X3*.**

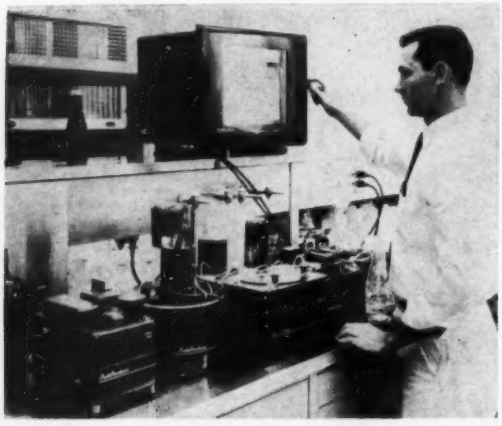
For further information, write for bulletins or call your nearest CEC sales and service office.

Transducer Division **CEC**

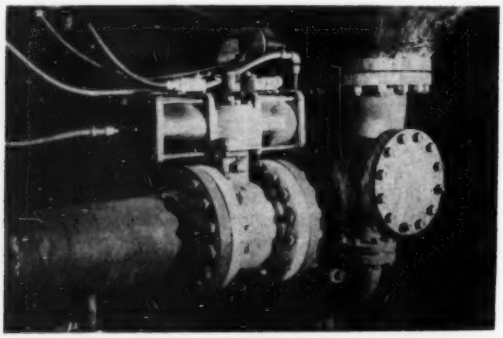
CONSOLIDATED ELECTRODYNAMICS / pasadena, california

A SUBSIDIARY OF Bell & Howell · FINER PRODUCTS THROUGH IMAGINATION

NEW APPLICATIONS



TECHNICON CONTROLS furnished an AutoAnalyzer electronic analytical system to H. J. Heinz Co. where by automatic determination it now provides a rapid check on product quality and uniformity of operations with a precision of ±1%.



JAMESBURY CORP.'s Double-Seal Ball Valves are finding extensive application at the St. Joe Paper Co. in Port St. Joe, Fla. for controlling the discharge of its ten digesters.

LEEDS AND NORTHRUP's K-3 potentiometer, with Wheatstone bridge, among the most accurate instruments of the kind now in industrial use, checks voltages of a

standard cell at the Martin Company's calibration laboratory. Laboratory equipment in turn is checked against "master" equipment at the U. S. National Bureau of Standards.

BARNES ENGINEERING (40 Commerce Rd., Stamford, Conn.) furnished the infrared radiation and horizon sensors abroad TIROS II, this country's latest weather satellite. At a special session of the American Meteorological Society, *Dr. Rudolph Hanel* of NASA's Goddard Space Flight Center revealed that evaluation of the six million infrared temperature measurements a day show that they correlate closely with known conditions and provide valuable weather data.

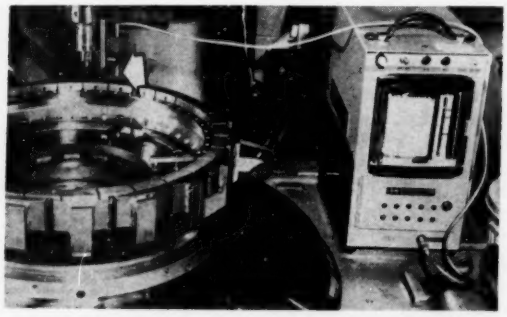
BENDIX G-20 USERS CONFERENCE, held in December in Beverly Hills, was highlighted by a demonstration of the Bendix G-20 and its accessories. Officers of the group were installed, including *Robert G. Noel* as chairman, and *Hubert D. White*, as secretary.

COMPUTER ENGINEERING ASSOCIATES, INC. is building a $90,000 thermal analog computer for Douglas Aircraft Co., Santa Monica, California, as an aid in solving various missile thermal problems. (Computer Engineering Associates, Inc., 1900 Beverly Blvd., Los Angeles 57, Calif.)

TRUE DIRECT WRITING was discussed by four speakers at the recent Cleveland Electronics Conference who presented papers on heated-stylus, electric, ink, and carbon-transfer methods.

CONTROL DATA CORP. is furnishing a Model 1604 Computer to the University of Wisconsin. Financing for the computing system whose total cost will be more than $1,000,000 has been made possible through a $500,000 grant from Wisconsin Alumni Research Foundation (WARF) and a $400,000 grant from National Science Foundation, with additional support coming from the U. S. Army Mathematics Research Center on the campus.

SHEFFIELD CORPORATION's Pneumatic Gage Recorder has been applied by General Electric's Evandale plant to eight automatic indexing jig bore machines. Each recorder is equipped with maximum and minimum toler-



ance lights, index chart drive, and a buzzer signal. The unit makes it now possible to transfer recorded dimensions to the inspection department to avoid additional inspection requirements. (The Sheffield Corp., Subs. of The Bendix Corp., Dayton 1, Ohio.)

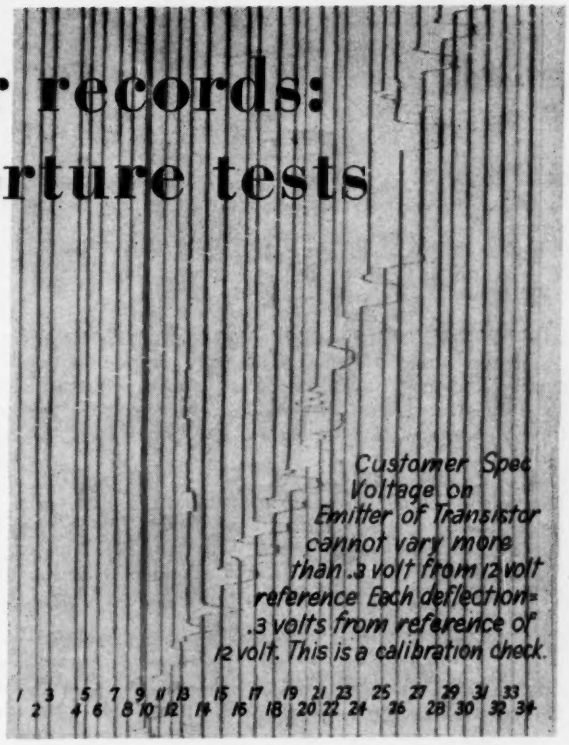
MINNEAPOLIS-HONEYWELL has helped Indiana General Corporation of Valparaiso to measure flux output with ¼% accuracy. Based on Indiana's research, M-H has engineered and built a Permanent Magnet Tester (PMT 400), a self-contained unit combining a Honeywell electronic potentiometer, a Hall probe, and a stable d-c voltage supply.

The Visicorder records: transistor torture tests

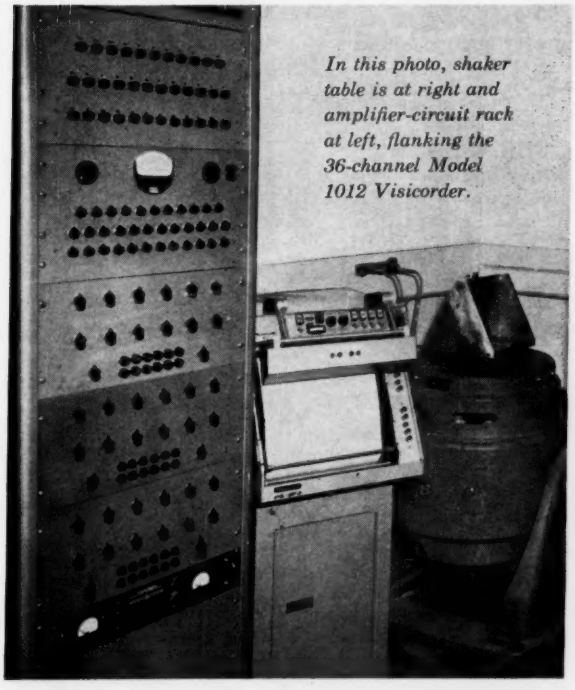
Transistors often have to work under incredibly severe environmental conditions. Production-testing them gave engineers at Honeywell's Semiconductor Division a chance to exploit the great versatility of the 36-channel Visicorder oscillograph Model 1012.

A certain order of transistors had to withstand vibrations of 10G at 10 to 2,000 cps without failing during the test or as a result of it. A standard test had been to measure the transistor's performance, next subject it to non-active vibration (not in any circuit), and then re-measure. This approach was obviously deficient as it did not reveal *operating* characteristics during test, nor did it disclose *intermittent*-type failures.

The customer's quality requirements were stringent (AQL = .4%) and the large test sample required ruled out the use of an oscilloscope. The 3-hour test would have made a battery of scopes and operators necessary; transient defects would be missed due to eyestrain, fatigue, etc.



Unretouched record of vibration test on 36 transistors, each active in its own circuit during test.



In this photo, shaker table is at right and amplifier-circuit rack at left, flanking the 36-channel Model 1012 Visicorder.

The Model 1012 Visicorder was chosen for the task as it simultaneously measures and records 36 channels of test information throughout the test period. The Visicorder instantly and directly records transients, no matter how random.

A Visicorder record like this is always a welcome supplement to your test data—your customer will be able to read it quickly and with full understanding. And it is a *permanent* record which *he* can show to *his* customer, if necessary.

For further information on how Visicorders can help to solve your instrumentation problems, contact your nearest Honeywell sales office without delay. Or write for Catalogs HC 906, 1012, 1108 and 1406, to:

Minneapolis-Honeywell, Heiland Division, 5200 East Evans, Denver 22, Colorado, SK 6-3681—Area Code:303

HONEYWELL INTERNATIONAL *Sales and Service offices in all principal cities of the world.*

Honeywell

H Industrial Products Group

CIRCLE 25 ON READER-SERVICE CARD

ICS NEWS

ELECTRONIC ASSOCIATES will hold a 2-week course on "Analog Computer Application to Chemical Process Problems" starting on March 27, 1961, at its Princeton Computation Center (P. O. Box 552, Princeton, N. J.). Tuition fee is $400; enrollment is limited to 25 students.

BOSTON COLLEGE will conduct the annual special two-weeks intensive course in modern industrial spectrography July 17-28, 1961. For further information write to Rev. James J. Devlin, S. J., Department of Physics, Boston College, Chestnut Hill 67, Mass.

OHIO VALLY EXHIBITION AND SYMPOSIUM—Instrument-Automation-Electronic—under the joint sponsorship of Cincinnati Section of the Society for Applied Spectroscopy and the ISA will be held April 11-12 in the Cincinnati Gardens. For further information write Paul D. Fleming, 2512 Homestead Place, Cincinnati, Ohio.

METROLONICS, INC. is holding special one-week courses in Training in Linear Metrology. For further information write MetroLonics' Laboratories, 2201 No. Hollywood Way, Burbank, Calif.

SOUTHWEST RESEARCH INSTITUTE (SFI), in cooperation with the Society for Experimental Stress Analysis, will hold an intensive short course in Strain Gage Techniques in San Antonio, April 17-21. Tuition for the lecture program is $175; tuition for the supplemental laboratory is $100. All applications and tuition must be in by April 10. Inquires should be addressed to Dr. M. M. Lemcoe, SRI, Box 2296, San Antonio 6, Texas.

OBITUARY

William D. Kelley

William D. Kelley, 36, technical director of Allegany Instrument Co., died February 2, 1960, when the plane he was piloting to Brigham City, Utah struck a mountain peak in Northern Utah during a sudden snow storm. Mr. Kelley was returning from a meeting of the American Rocket Society in Salt Lake City. During his fifteen years in the field of rocket instrumentation, Mr. Kelley had achieved notable professional recognition. Bill Kelley is survived by his wife and six children.

OBITUARY

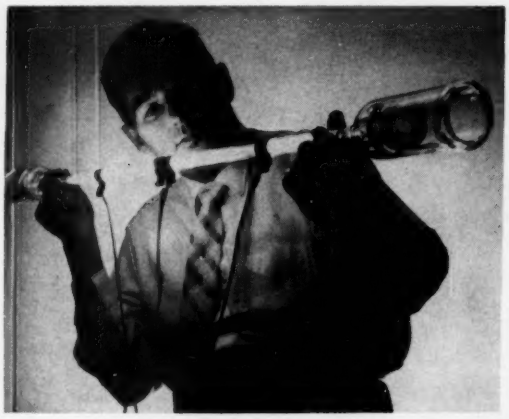
Noel Lee Isenhour

Noel Lee (Tiny) Isenhour, 47, succumbed to a sudden heart attack February 6. "Tiny," as he was affectionately known to all of us in the field of industrumentation, was superintendent of the Instrument Department, Maintenance Division, at the Oak Ridge Gaseous Diffusion Plant of Union Carbide Nuclear Corp.

"Tiny" was a member of several technical and engineering societies and technical committees, and was Vice President of the ISA from 1950 to 1952.

Optical Maser

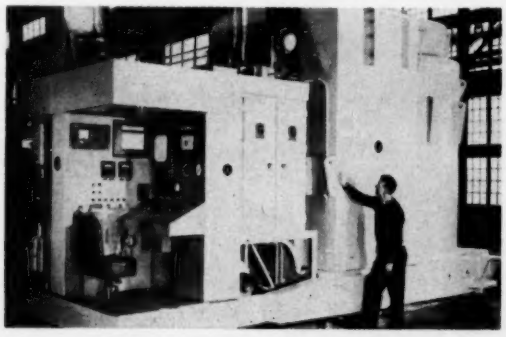
NEW YORK, N. Y.—The first continuously operating optical maser was demonstrated recently by Bell Telephone Labs. "Maser" (microwave amplification by stimulated emission of radiation) is a device for amplifying electromagnetic waves like light and radio signals.



The new gas maser uses a mixture of helium and neon gas to achieve continuous operation. Operating on less power than an ordinary light bulb, it continuously generates a coherent beam of infrared light. This beam, several hundred thousand times narrower in frequency, or purer in color, than any other coherent light source, promises to be one of the most efficient information carriers ever conceived. Previous optical masers (built around crystals) required thousands, even millions of watts of power to transmit large bursts of visible light of very short duration.

Service Vehicle

PHILADELPHIA, PA.—A unique, $700,000 vehicle for loading atomic fuels and removing highly radioactive atomic wastes was built by Baldwin-Lima-Hamilton's Industrial Equipment Div. Called a transfer cask car, it will be used by the Enrico Fermi station, being built for the Power Reactor Development Co.



Major sections of the car include: (1) a large, shielded cylinder where handling and carrying of the fuel elements is accomplished; (2) the heat transfer system; and (3) a control cab, accommodating the operator and a console grouping of all instruments and controls.

It was necessary to design a special 10″-dia. ball valve which is molecule-tight (that is, totally leak-proof). The ball for this valve is of depleted uranium, ground to an 8-micro-inch finish. (Baldwin-Lima-Hamilton Corp., Eddystone, Philadelphia 42, Pa.)

VERSATILE WESTON RECORDER HANDLES 2 TO 24 POINTS—WITH EASY INTERCHANGEABILITY

Industry's leading recorder, the Weston Model 6702—has proved its versatility in more than two years of in-service operation. The first recorder of its kind, it accommodates up to 24 points in a single, compact unit. Number of points can be changed quickly. Accuracy is within ±0.25% of span or ±.025 mv on potentiometer.

Model 6702 features simplicity of design and performance. It has replaceable range standards and a plug-in amplifier. Printing and chart speeds are easily changed. Other advantages include the Weston D-PAK (T.M.) which eliminates standard cells, batteries and standardizing mechanisms . . . and a unique printed circuit switch is geared directly to the printing head.

Model 6702 is 39% smaller than the average multi-point recorder, and offers the convenience of rack mounting. It is designed and manufactured with traditional Weston craftsmanship to provide years of dependable, trouble-free service.

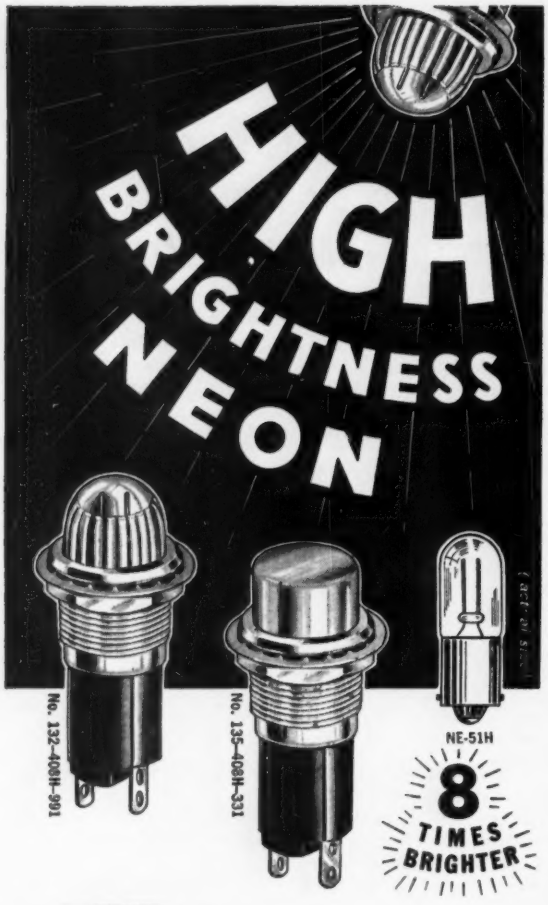
Ask your local Weston representative for details on this and other Weston instruments for industry, or write for Catalog 08-101. Daystrom, Incorporated, Weston Instruments Division, 229 Manchester Road, Poughkeepsie, N. Y. *International Sales Division, 100 Empire St., Newark 12, N. J. In Canada: Daystrom Ltd., 1480 Dundas Highway East, Cooksville, Ontario.*

PROVED
in more than 2 years of service operation

Model 6702 uses full-size chart. Points: 2, 3, 4, 6, 8, 10, 12, 14, 16, 18, 20, or 24. Printing speeds: 3 to 60 seconds per point, readily changed. Operation: 115 volts, 60 cycles or 115 volts, 50 cycles.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION
Reliability by Design

CIRCLE 26 ON READER-SERVICE CARD



DIALCO PILOT LIGHTS

with Built-in Resistor

(a patented DIALCO feature)

for the Neon Glow Lamp NE-51H (High Brightness)

RUGGED: The NE-51H Neon Glow Lamp is made to resist vibration and is proof against sudden failure. It may be operated at about 3 times the level of current applied to the standard neon lamp, and it will produce 8 times as much light—*with long life!* Requires low power—less than 1 watt on 250 V circuit. Recommended for AC service (may be used on DC circuits above 160 V).

BUILT-IN current-limiting resistor (U. S. Patent No. 2,421,321): For use on 105-125 volt and 210-250 volt circuits. In DIALCO Pilot Lights, the built-in resistor is completely insulated in moulded phenolic and sealed in metal.

COMPACT: Units are available for mounting in 9/16" and 11/16" clearance holes...in a wide choice of lens styles and colors, terminal types, metal finishes, etc. Meet applicable MIL Spec and UL and CSA requirements.

Every assembly is available complete with lamp.

SAMPLES ON REQUEST—AT ONCE—NO CHARGE

Ask for Bulletin No. 100 and Catalogue L-161B.

Foremost Manufacturer of Pilot Lights

DIALIGHT CORPORATION

42 STEWART AVE., BROOKLYN 37, N. Y. • HYacinth 7-7600

Booths 2829-2831 At The IRE Show

CIRCLE 27 ON READER-SERVICE CARD

IQS STOCK REPORT

Further information may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

NEW YORK STOCK EXCHANGE

PRICE RANGE FOR 1961 THRU FEBRUARY 16, 1961

	High	Low	Price As Of 2/16/61
ACF Industries	53 7/8	35 1/8	51 3/8
Aeroquip Corp.	40 5/8	22	31
Allis Chalmers	40	22	26 5/8
American Chain & Cable	51 3/4	40 1/4	47 3/4
Amer. Mach. & Foundry	100	49 1/2	98 1/4
Amer. Mach. & Metals	58 1/4	31 3/4	43 3/4
American Optical	67	43 1/4	57 1/4
American Tel. & Tel.	117	79 7/8	115 3/4
Ampex Corp.	42 1/4	19 1/2	20 1/2
Aro Equipment	25 7/8	19	24 7/8
Bauch & Lomb Optical	58 7/8	34 1/2	44 1/2
Beckman Instruments	111 1/2	62 1/2	109 1/2
Bell & Howell	60 1/2	37 5/8	60
Bendix Aviation	74 1/2	56 1/4	67 1/4
Boeing Airplane	42 1/4	23	41 1/4
Bullard	17 7/8	10 3/8	14 7/8
Bulova Watch	23 3/4	14 1/8	17 1/8
Burroughs	40 3/8	26 1/4	34 3/8
Carborundum	50 1/4	39 1/4	48 5/8
Cinn. Milling Machine	49	26 1/2	49
Clevite	72 1/2	42	52 7/8
Columbia Broadcasting Sys.	45 1/4	34	38 3/4
Consol. Electronics	60 3/4	39 1/2	43 5/8
Corning Glass	186	124	178
Curtiss Wright	31 1/8	14 5/8	18 7/8
Cutler-Hammer	96	62 3/8	67 1/2
Daystrom	49 3/8	27 1/2	31 3/4
Douglas Aircraft	42 3/8	27	33 3/8
Eastman Kodak	136 1/4	94	107 1/2
Eaton Mfg.	46 7/8	28 1/2	34 3/4
Electric Auto-Lite	54 1/2	44 1/2	50 7/8
Elgin Watch	19 1/8	10 1/2	13 1/4
Emerson Electric	66 1/2	33	64
Engelhard Industries	23	16 3/4	21 7/8
Food Mach. & Chem.	67	44 1/2	63 7/8
Garrett	59	42 1/8	51 1/4
General Controls	29 5/8	15 3/4	18 5/8
General Dynamics	83 3/8	33 1/2	43 1/8
General Electric	99 7/8	61 1/8	65 1/2
General Instruments	50 3/8	22 1/2	44 1/8
General Mills	35 5/8	23 7/8	35 1/4
Gen. Precision Equip.	68	43 1/2	68
Gen. Railway Signal	38 1/2	23 1/4	38
Gen. Tel. & Elect.	34 1/8	23 3/4	28 1/4
General Time	33 1/8	12 1/2	17 7/8
General Tire & Rubber	81 3/8	41 5/8	63
International Bus. Mach.	658	407 1/4	641 1/2
International Resistance	41 5/8	18 1/4	33 7/8
Internat'l. Tel. & Tel.	52 1/2	32	51 3/4
I-T-E Circuit Breaker	44 1/4	18 1/8	23
Lear Inc.	23 1/2	13 5/8	17 7/8
Litton Industries	102 3/8	57 5/8	100 1/4
Lockheed Aircraft	35 7/8	18 5/8	34 7/8
Magnavox	61 5/8	31 3/4	60 1/2
Mallory	50 1/4	33	43
Manning, Maxwell & Moore	27 1/2	19 5/8	25 3/8
Minneapolis-Honeywell	178 3/4	123 5/8	154
Minnesota Mining & Mfg.	88	60	77 7/8
Motorola	98	60 1/2	81 3/4
National Acme	56 1/4	40	56 1/8
National Cash Register	76	49 7/8	74 1/4
Naptune Meter	34 3/8	22 7/8	24 1/8
North American Aviation	51 1/8	29 5/8	51 1/8
Northrop Aircraft	47	24 3/4	45 5/8
Otis Elevator	72 1/4	36 3/4	71
Philco Corp.	38 1/4	15 7/8	21 5/8
Radio Corp. of Amer.	78 3/8	46 1/2	54 7/8
Raytheon Mfg.	53 3/8	30 1/4	38 3/8
Reliance Electric	68 5/8	43 1/8	53 1/2
Rheem Mfg.	28 7/8	12	17 3/4
Robertshaw Fulton	55	33 1/4	35 1/2
Royal Mc Bee	21 3/8	11 7/8	15
Sangamo Electric	21 1/2	13 1/8	15 3/4
Siegler Corp.	43	23 5/8	31 3/8
Sperry Rand	26 1/4	18 3/8	24 1/4
Square D	37 7/8	25 1/2	30 3/4
Standard Kollsman	30 1/2	12 5/8	27 1/2
Starrett (L. S.)	20	16	17 3/4
Stewart-Warner	33 1/2	23	27 1/2
Telautograph	24 1/2	6 7/8	12 7/8
Texas Instruments	256 1/4	148 1/4	180
Thompson-Ramo-Wooldridge	82 3/8	46 7/8	81 7/8
Tung-Sol Electric	40 1/2	25 3/8	26 1/8
Underwood Corp.	57	23 3/4	46 3/4
Union Carbide Corp.	148 1/2	106 1/2	124 1/4
United Shoe Machinery	64 3/8	50	64 1/2
Varian Associates	67 1/2	38 1/8	57 3/4
Wallace & Tiernan (new) (a)	35	26 1/2	35
Western Union	57	38 1/4	44 1/2
Westinghouse Air Brake	32 5/8	21 1/8	24 1/2
Westinghouse Electric	65	40 5/8	45 1/8
Worthington Corp.	66	41 1/2	57 1/4

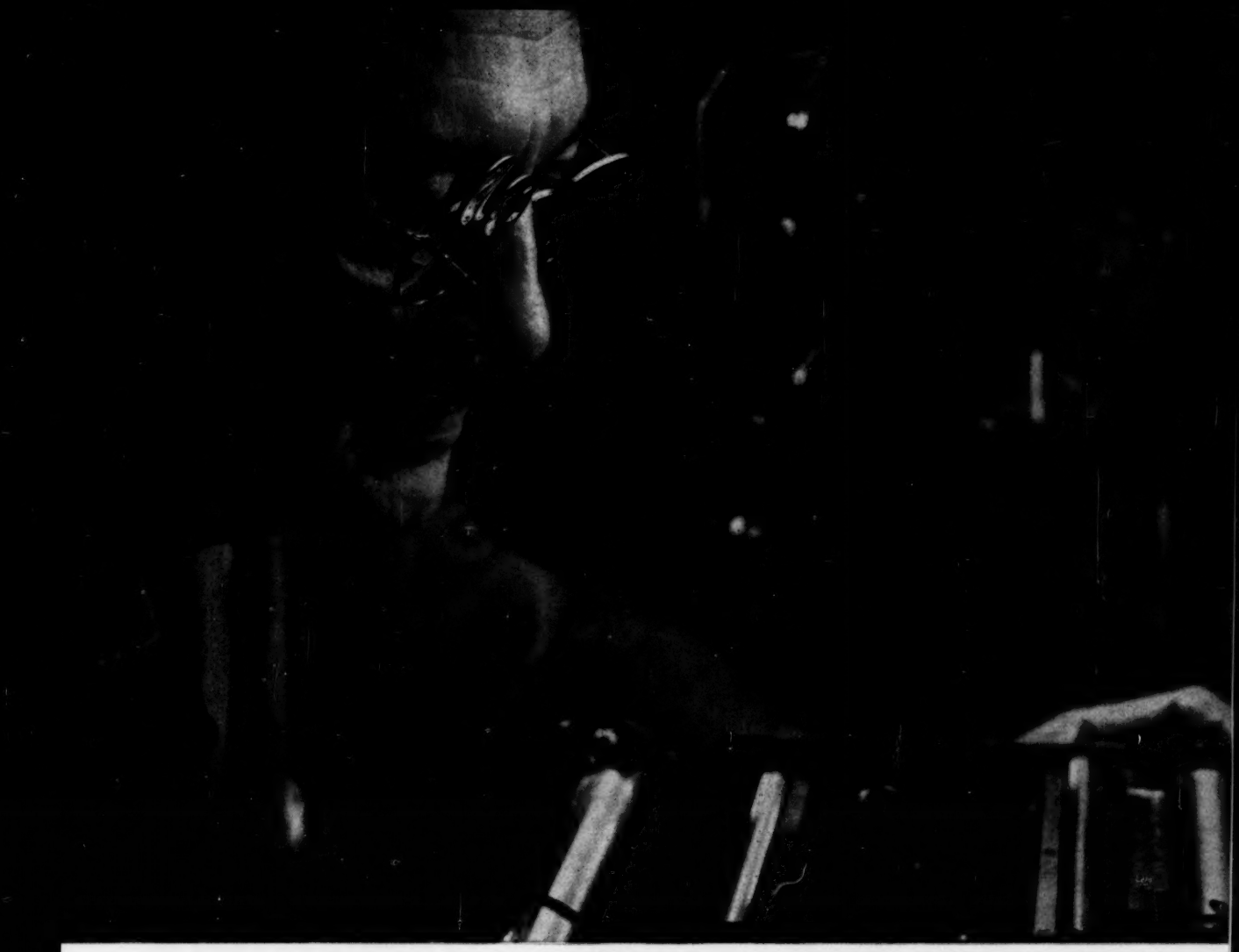
These prices and price ranges are given as printed in the Wall Street Journal.

AMERICAN STOCK EXCHANGE

PRICE RANGE 1961 THRU FEBRUARY 16, 1961

	High	Low	Price As Of 2/16/61
American Meter	52	39	47
Barry Wright Corp.	25 1/2	13 5/8	17 3/8
Belock Instruments	25 3/8	13 1/8	15 3/8
Benrus Watch	8 7/8	5 3/8	6 1/4
Breeze Corp.	8 5/8	4	5 1/8
Burnell & Co.	9	6	9
Clark Controller	23 5/8	15 1/2	18

(*Continued on Page 397*)



Arch Heiss, Master Craftsman at Esterline Angus for 26 years

Experienced Craftsmanship

. . . solid foundation for reliability and performance

Standing solidly behind the creative designs of our engineering staff are our 50-plus years of experience . . . the highly-developed skill and attention to detail of our master craftsmen.

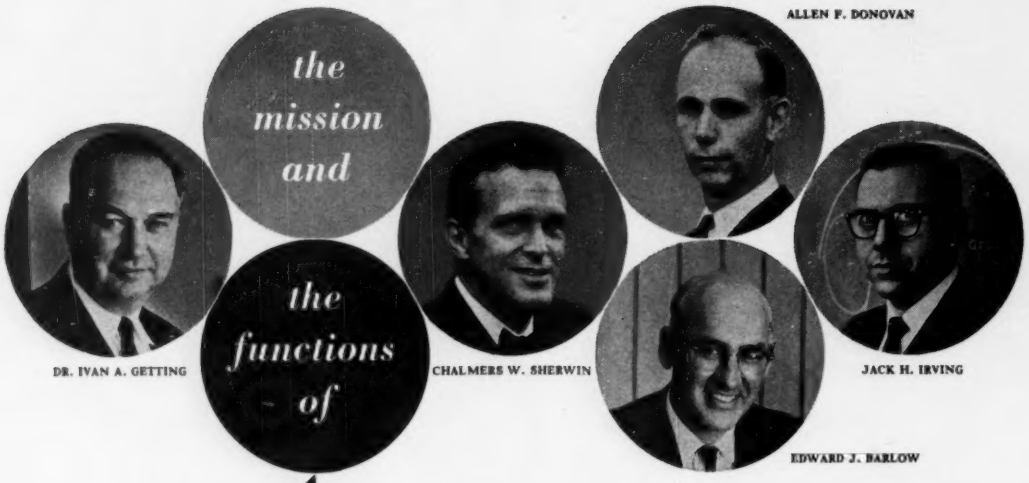
An example of our meticulous care: Mr. Heiss is shown above making a final check on a chart drive mechanism, the heart of any recording instrument. To insure its accuracy and its ability to withstand rugged industrial use, this delicate device like all others in our precision instruments is manufactured in our own plant. At any of the five standard hour speeds, the timing accuracy is of the order of 99.95% per week!

For dependable, trouble-free performance covering a wide range of applications, insist on modern Esterline Angus recording instruments—the highest reliability rating in the industry.

New Analog-Event Recorder—Now, *one* instrument does the work of *two*. Write for descriptive folder. Address: ESTERLINE ANGUS INSTRUMENT COMPANY, INC., Box 596G, Indianapolis 6, Indiana.

Excellence in graphic recording for over 50 years—ESTERLINE ANGUS

CIRCLE 26 ON READER-SERVICE CARD



AEROSPACE CORPORATION

present genuine challenge to scientists and engineers of demonstrated competence

"To preserve our free institutions, it is absolutely essential that the United States find the most effective means of advancing the science and technology of space and also of applying them to military space systems. This is the mission of Aerospace Corporation."

IVAN A. GETTING
PRESIDENT
AEROSPACE CORPORATION

In accomplishing its mission, this nonprofit public service organization performs the unique role of space systems architect. Aerospace Corporation provides scientific and technical leadership to the science/industry team responsible for developing complete space and ballistic missile systems on behalf of the United States Air Force.

Specific responsibilities of the new corporation include advanced systems analysis, research and experimentation, initial systems engineering, and general technical supervision of new systems through their critical phases.

The broad charter of Aerospace Corporation offers its scientists and engineers more than the usual scope for creative expression and significant achievement, within a stimulating atmosphere of dedication to the public interest.

Aerospace Corporation scientists and engineers are already engaged in a wide variety of specific systems projects and forward research programs, under the leadership of scientist/administrators including corporation president Dr. Ivan A. Getting, senior vice president Allen F. Donovan, and vice presidents Edward J. Barlow, William W. Drake, Jr., Jack H. Irving, and Chalmers W. Sherwin.

Aerospace Corporation is currently seeking scientists and engineers capable of meeting genuine challenge and with proven ability in the fields of:

- Space booster project engineering
- Spacecraft design and analysis
- Aerothermodynamics
- High temperature chemistry
- Nuclear rocket propulsion
- Ion and plasma propulsion
- Chemical propulsion
- Inertial guidance
- Space communication
- Experimental physics
- Theoretical physics

Those qualified and experienced in these and related fields are urged to direct their resumes to:

Mr. James M. Benning, Room 125
P.O. Box 95081, Los Angeles 45, Calif.

A new and vital force AEROSPACE CORPORATION *engaged in accelerating the advancement of space science and technology*

(*Continued from* 394)

Clarostat Mfg.	16 3/8	9 7/8	14 3/8
Clary Corp.	11 1/2	8 3/4	9 7/8
Cubic Corp.	69	39 5/8	63 1/2
Dynamics Corp. of Amer.	13 3/4	6 5/8	9 1/8
El-Tronics	8 1/8	4	8 3/4
Electronics Corp. of Amer.	19 1/2	8 1/8	10 7/8
Fairchild Camera & Instrument	201 3/4	110 1/4	140 1/2
Fischer & Porter Co.	24 5/8	16	23
Giannini Controls	68 3/8	39	62
Globe Union	34 3/4	20 5/8	26 7/8
Hazeltine Corp.	33	20	33
Loral-Electronics (new) (a)	40 1/8	23 1/8	40 1/8
National Research	27 1/8	13 1/8	26 3/4
New Haven Clock	2 7/8	1	1 1/8
Nuclear Corp. of Amer.	5 3/8	2 1/8	4 1/2
Philips Electronics, Inc.	47 3/8	31 1/2	37 5/8
Pneumatic Scale	59 3/4	35	42 1/2
Polarad Electronics	36 5/8	17	22 1/2
Servo Corp. of Amer.	24 1/2	9 1/4	13 3/4
Servomechanisms	16	7 1/2	10
Statham Instruments Inc.	40 1/4	28 3/4	30 1/4
Textron Electronics	18 3/4	8 5/8	10
Victoreen Instrument Co.	17 1/2	9 3/4	15 1/8
Waltham Prec. Instr. Co.	3 1/2	1 1/2	1 7/8

These prices and price ranges are given as printed in the Wall Street Journal.

Barry Controls merged with Wright Line, Inc., new name is Barry Wright Corp.

OVER THE COUNTER

	Quotation As of February 16, 1961 Bid	Asked
Aerovox Corp.	10 1/8	10 5/8
Argus Corp.	37 1/8	37 3/8
Black Sivalls & Bryson Inc.	14	14 1/2
Computer Systems	10 1/4	11 1/4
Kitel Mc Cullough	17 3/4	18 1/4
Electro Instruments	30	31 1/2
Electronics Associates	33 1/2	34 1/4
Erie Resistor Corporation	15 1/8	15 1/2
Fisher Governor Co.	20 3/4	21 1/4
Foxboro Company (new)	53 1/2	55
Hagan Chemicals & Controls	49 1/2	51
Milgo Electronic Corp.	23	23 3/4
Industro Transitor	4 1/2	4 7/8
Liquidometer Corp.	12 1/2	14
W. L. Maxson	14	15
Hewlett-Packard Co.	29 3/4	30
Penn Controls	21 1/2	23
Speer Carbon, Inc.	18 3/4	19 1/2
Sprague Electric	59 1/2	60 1/2
Taylor Instruments (new)	44	45 1/2
Telechrome Mfg. Corp.	13 5/8	14 1/8
Telecomputing Corp.	7 1/4	7 5/8
Vitro Corp. of Amer.	15	15 1/2

CUSTOM-BUILT AS A LIMOUSINE: Each ALPA Camera is literally made to your order, with all the skill and experience of Swiss Master Craftsmen.

CONVENIENT AS A FAMILY CAR: Fingertip controls, built-in exposure meter and large brilliant groundglass image —for practically automatic through-the-lens framing, focusing and depth-of-field control.

VERSATILE AS A JEEP:

10 Automatic Diaphragm lenses from 24mm to 180mm (other lenses up to 5000mm) PLUS a continuous focusing range from infinity down to ultra close-ups and photomicrography, **without gap.**

COLORFUL AS A CONVERTIBLE:

5 APOCHROMATS—Switar and Macro-Switar 50mm f/1.8, Kinoptik 75mm f/2, 100mm f/2 and 150mm f/2.8—offer exclusive correction of all 3 primary colors.

FAST AS A RACING CAR: 1:1 LIFESIZE image, straight 0° viewing, split-image rangefinder, lightning reflex mirror, hair-trigger release, quick-change lenses w/Automatic Diaphragms, rapid-wind lever and high-speed rewind crank with parallelogram.

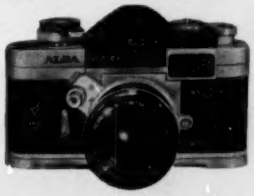
SHARP AS A SPORTSCAR: Each ALPA lens is individually film-tested for critical

sharpness, perfect tonal contrast and brilliant overall illumination.

STURDY AS A TRUCK: Rugged Swiss precision mechanism withstands extreme wear, temperatures and shock, limiting repairs to an absolute minimum.

COMPACT AS A SMALL-SIZE CAR: Lightweight (1½ lbs.) and compact (5¾" x 3¾" x 2"), ALPA combines all the features of the THREE most advanced camera types — Single-lens Reflex, Twin-lens Reflex and Rangefinder — in ONE camera . . .

THE NEW ALPA 6c ALL-IN-ONE 35mm CAMERA



karl heitz

480 LEXINGTON AVE., NEW YORK 17 • YUkon 6-4920

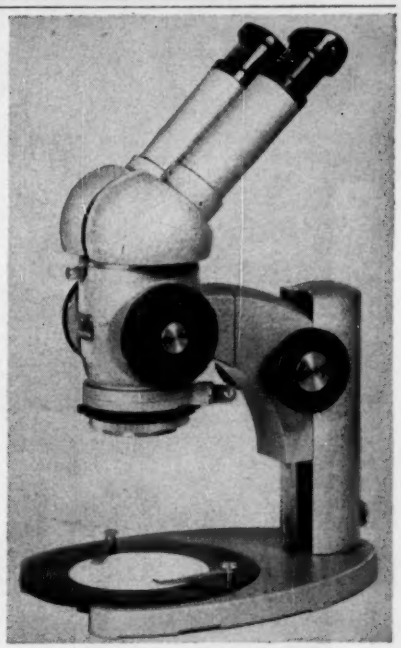
Please write for free illus. brochure ICA-3 *or see your franchised ALPA dealer.*

CIRCLE 29 ON READER-SERVICE CARD

New CARL ZEISS

STEREO-MICROSCOPE II

MADE IN WEST GERMANY



This sturdy, compact instrument produces an image of outstanding plasticity—erect, unreversed, and uniformly sharp over the entire field of view. It is easy on the eyes, even under prolonged observation.

Offers novel, rapid change of magnification from 2.5x to 100x, with wide-angle oculars.

Affords a large working distance—3-1/8 inches—with diameter of object field up to 50mm. Beyond 100x magnification, a 2x supplementary objective is available, having a working distance of 1-1/8".

Write for literature which gives complete details

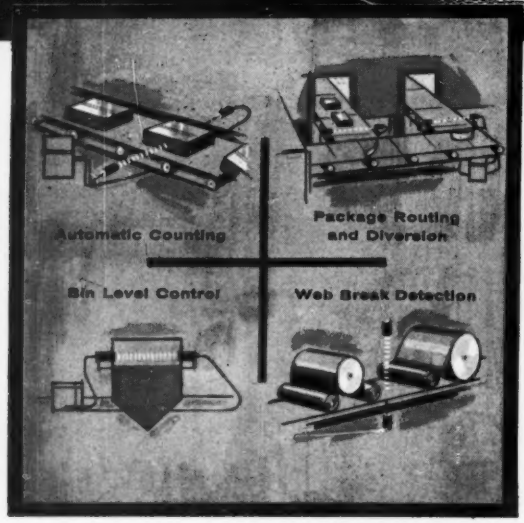
CARL ZEISS, INC. COMPLETE SERVICE FACILITIES

485 FIFTH AVENUE, NEW YORK 17, N. Y.

CIRCLE 30 ON READER-SERVICE CARD

a new dimension in automated controls

Patents Pending

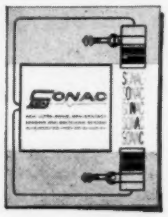


SONAC ULTRASONIC,

NON-CONTACT SENSING AND SWITCHING SYSTEM

Before Sonac, sensing and switching control systems which involved breaking a beam of energy were limited by vibration, dust, smoke, steam, air contamination and too much or too little light. Sonac's ultrasonic energy "beam" is completely free of these limitations. The acoustic lens on Sonac sensors can actually be painted without affecting performance. Utilizing high frequency sound also means there are no lamps to burn out. Savings in replacement parts and maintenance time often means Sonac pays for itself. Sonac is completely transistorized, providing you with a rugged, dependable electronic circuit.

These are just a few of Sonac's many uses. Optional equipment includes reflectors for precision beam and positioning control, and coupler assemblies for use with flexible tubing for remote sensor locations. This descriptive booklet will be sent to you on request.

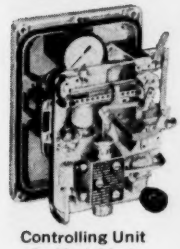


DELAVAN
Manufacturing Company
WEST DES MOINES • IOWA

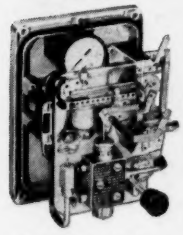
CIRCLE 82 ON READER-SERVICE CARD

Recording Unit for Variable 1

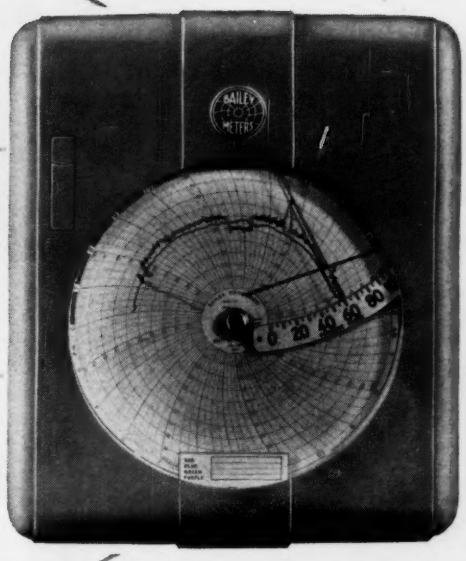
Recording Unit for Variable 2



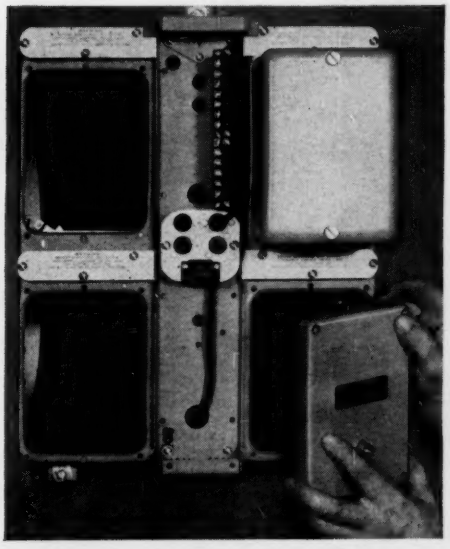
Controlling Unit for Variable 1



Controlling Unit for Variable 2



Back of Bailey Recorder, showing how four plug-in units may be added as needed.



Key to "step-by-step" automation . . .

BAILEY RECORDERS

with plug-in flexibility

When you are pioneering a new process and don't know all the answers, complete automation is seldom practical. The first step is to identify your variables and measure them. Nothing does this job better than a Bailey Recorder. One instrument can record any four variables that can be converted to electric *or* pneumatic signals.

Then you will want to add controls and feed back your measurements. Here's where the versatility of the Bailey Recorder comes into play. For the same Bailey instrument you use to record variables is designed to accommodate plug-in control units.

When you use a Bailey Recorder, you can build your instrumentation along with your process. At the start, you use only the plug-in units for recording. Then you add plug-in controls as you see the need for them.

For the complete story of how you can use a Bailey Recorder for step-by-step automation, contact your local Bailey Engineer.

G154-1

Instruments and controls for power and process

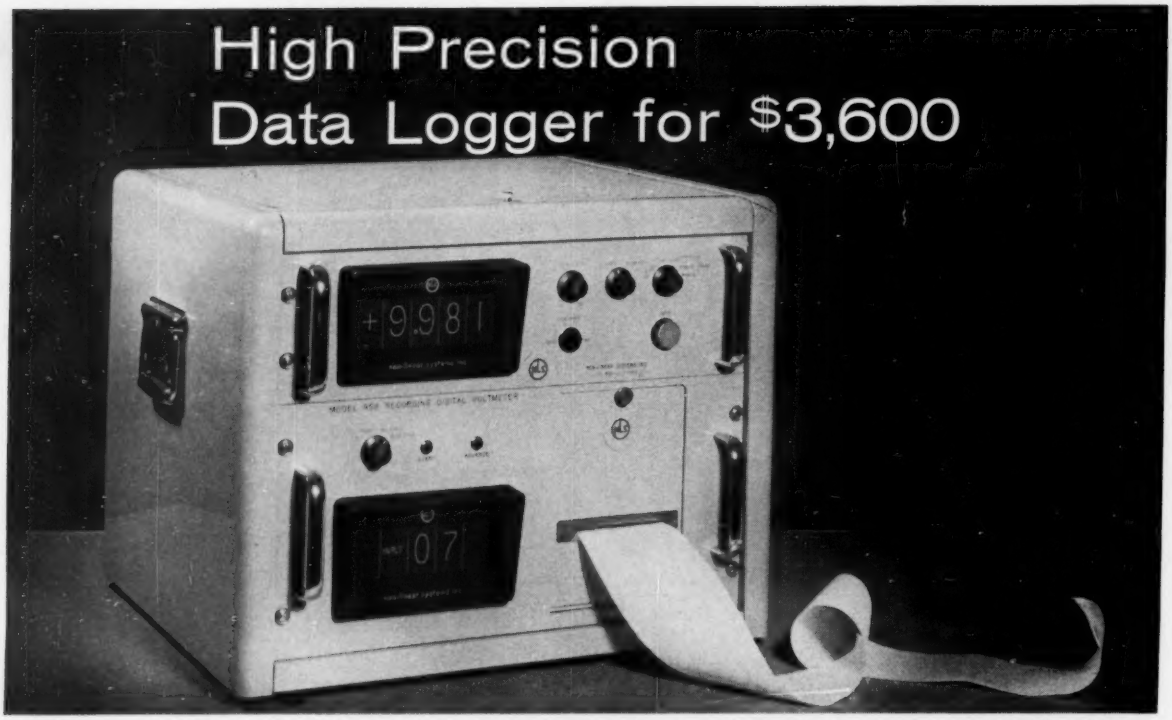
BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

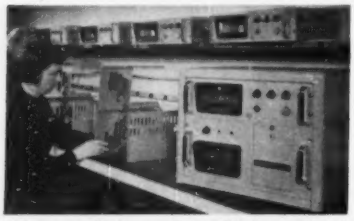
In Canada—Bailey Meter Company Limited, Montreal

CIRCLE 31 ON READER-SERVICE CARD

High Precision Data Logger for $3,600

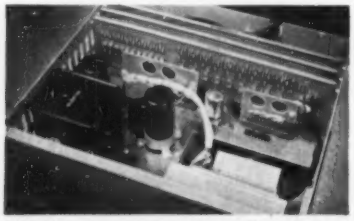


The RS2 Recording Digital Voltmeter – now in volume production at Non-Linear Systems, Inc. – scans up to 20 double-pole input channels . . . measures DC voltage from ±0.001 to ±999.9 with ±0.01% accuracy . . . and records input channel number and the 4-digit voltage measurement. Uses include research and development, quality control, environmental and reliability testing.



Volume production and simplified controls of the RS2 account for its low cost – half to a third less than custom-built units.

Plug-in stepping switches in the digital voltmeter section of the RS2 permit replacement of all switches and decade resistors in minutes instead of days.



Note the compact, plug-in modular design of the scanner-printer section of the RS2.

NLS Reports on Low-Cost, Standard Data Logger

A low-cost automatic data logger built as an integrated scanning, measuring and printing system – the RS2 Recording Digital Voltmeter – is now in volume production at Non-Linear Systems, Inc.

This economy-priced NLS logger is designed for applications requiring high accuracy and low cost without need for the higher speed and greater input capacity of higher cost NLS systems. Simplified controls offer several automatic and manual modes of operation to meet the needs of a great number of applications.

While utilizing many circuits field-tested for six years in thousands of NLS digital voltmeters, the RS2 has undergone extensive testing as a standard, complete system. It is delivered ready to use, without need for additional engineering or complex interconnections.

Call your NLS regional office or representative for a demonstration, or write NLS.

RS2 BRIEF SPECIFICATIONS

Visual Indication: 4-digit voltage reading with correct polarity and range. 2 digits for input channel identification.
Range-Polarity Indication: automatic
Functions: scanning up to 20-double-pole channels; measuring DC voltage from ±0.001 to ±999.9 in ranges of ±9.999/99.99/999.9; printing channel number, 4-digit reading, polarity and decimal point placement.
Accuracy: ±0.01% of full scale on each range.
Speed: 2 seconds average for each data point scanned, measured and recorded.
Scanner Operation Modes: AUTO CYCLE – system continually repeats automatic scanning cycle from channel 00 to 19. ONE CYCLE – system automatically stops after scanning channel 19. PRINT – one input is measured without advancing scanner. Scanner may be manually advanced one channel at a time by depressing front panel ADVANCE button.
AC Voltage: Use NLS AC/DC Converter.
Low-Level DC: Use NLS Model 140 Preamplifier.
Input Impedance: 10 megs on all ranges.
Size: 14" high, 15¼" deep for 19" rack.
Delivery: From stock. 30 days, maximum, should stocks become depleted.

See the new RS2 at IRE, Booth 3041-42.

Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR, CALIFORNIA

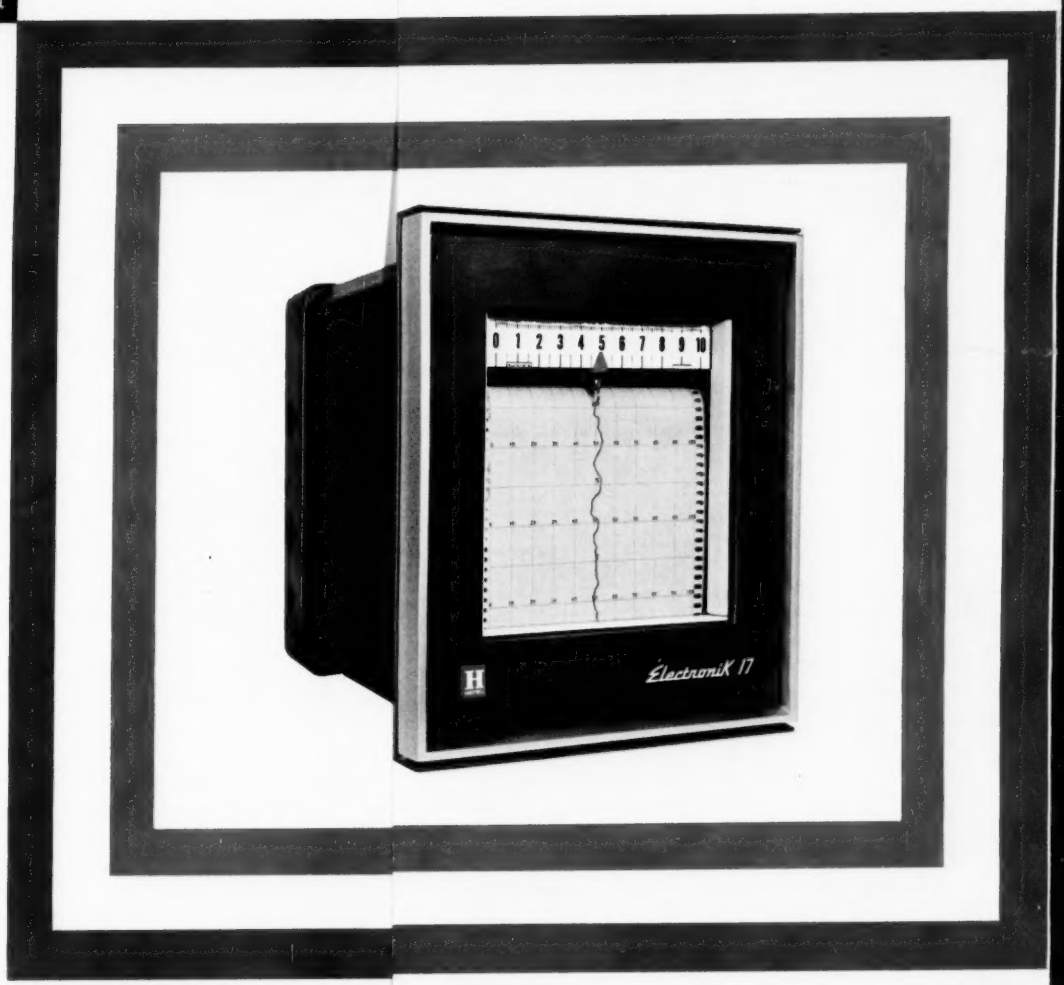
CIRCLE 32 ON READER-SERVICE CARD

CIRCLE 33 ON READER-SERVICE CARD——→

Now you can get . . . revolutionary rebalancing unit . . . modular construction . . . ±0.25% accuracy . . . in a small-case potentiometer . . . the advanced all-new

ElectroniK 17*

HONEYWELL



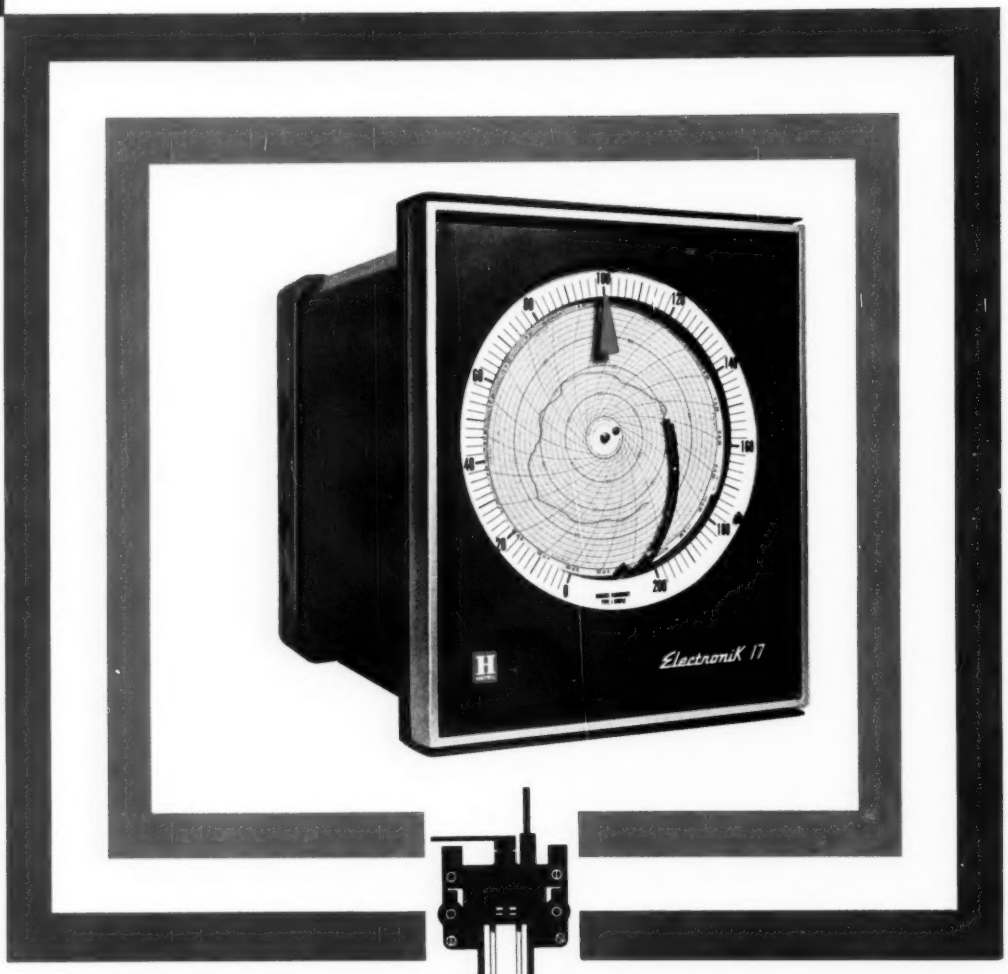
Now you can get . . . revolutionary rebalancing unit

. . . modular construction . . . ±0.25% accuracy . . .

in a small-case potentiometer . . . the advanced all-new

The ElectroniK 17 will save you more time, trouble,*

HONEYWELL



- N
- N
- N
- N

. . .

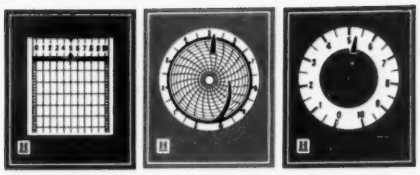
Electr
new
ment
relay
±0.2
new
easie
vert,

You
or ci
indic
with
plug-

With
only
save
and
tenti
than
page

*Trad

NO SLIDEWIRE, NO SLIDEWIRE PROBLEMS. The unique
element, an innovation in potentiometer design, replaces
works on the strain gage principle and consists of four l
the resistance legs of a Wheatstone bridge. Both STRAN
linked to the potentiometer balancing motor. A change
balancing motor to change the tension—and electrical resis
This in turn causes the balancing motor to rebalance the
sitioning the instrument pen or pointer. The STRANDU
atmospheres and has no contactors. It has unusually lo
and is unaffected when the instrument is subjected to amb



ble, dollars and maintenance than any other potentiometer on the market today.

- New STRANDUCER* replaces slidewire
- New control system with plug-in units
- New modular construction
- New economy

. . . and other pace-setting features.

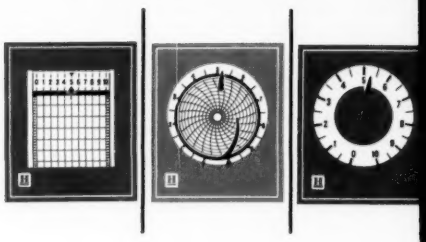
ElectroniK 17 potentiometers are completely ew Honeywell recording and control instruents, compact enough to fit standard 19-inch elay racks. They perform reliably, have ±0.25% calibrated accuracy, and incorporate ew design advances which make them the asiest of all potentiometers to operate, conert, and maintain.

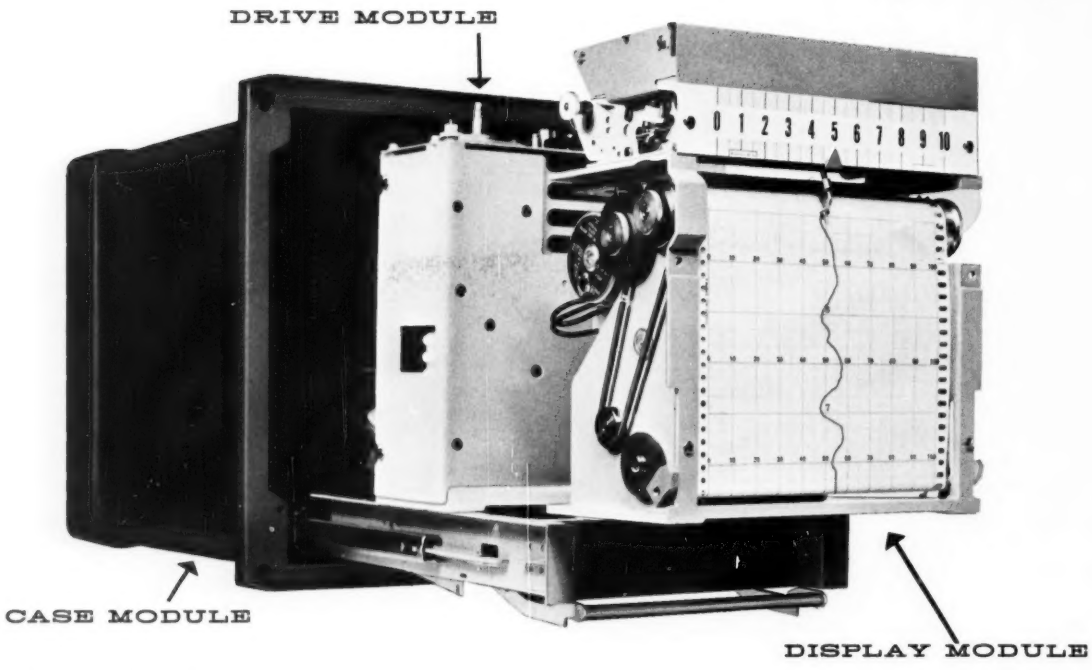
You can get *ElectroniK 17* instruments as strip r circular chart recorders or circular scale ndicators. You can get electric contact control vith up to 8 contacts. Control units are of lug-in type.

With *ElectroniK 17* potentiometers, you not nly get uninterrupted performance, but also ave money in initial cost, operating expense, nd maintenance. You will find this new poentiometer far more economical to operate han any other available today. The following age will tell you why.

Trademark

nique STRANDUCER rebalancing places the conventional slidewire. It our looped wire strands which form TRANDUCER and pen carriage are hange in electrical input causes the resistance—of the STRANDUCER. e the bridge, at the same time repoNDUCER is unaffected by corrosive lly long life and infinite resolution, ambient temperatures up to 130°F.





MODULAR CONSTRUCTION. *Modular construction and plug-in components make the ElectroniK 17 the easiest of all potentiometers to operate, convert, and maintain. Component interchangeability cuts service downtime, minimizes spare parts inventory.*

WIDE CONTROL POSSIBILITIES. You can have up to 8 control relays. Up to 8 plug-in contact control units fit into inside back of case.

INTERCHANGEABLE DISPLAY MODULE. You can switch easily from strip to circular chart, to circular scale operation . . . reduce your spare parts inventory because you can stock a single spare module for several instruments.

FRONT ADJUSTMENTS. You adjust damping and gain from the front of the instrument, using only a screwdriver.

QUICK-CHANGE DRIVE GEARS. You can change chart speed to ½ or 2 times basic speed in a matter of seconds by replacing quick-change drive gears. Standard basic chart speeds: 1, 2, 6, 10, or 60 inches per hour.

EASY RANGE AND ACTUATION CHANGE. Simply change range card attached to actuation board. A screwdriver is all you need. Universal reference junction compensator serves *all* types of thermocouples; you can quickly remove it to convert to some actuation other than thermocouple. Filter network rejects loop stray signals.

COMPACT EASILY-REMOVED TRANSISTOR AMPLIFIER. With only a screwdriver you can remove the amplifier for servicing.

NO STANDARDIZATION. Zener diode constant current unit does away with need for battery and standardizing mechanisms.

COMPACT CASE SAVES SPACE. With a height of 13¼ in., a width of 11 in. and a depth of 16⅝ in., the *ElectroniK 17* fits a standard 19-inch relay rack. Attach carrying handle to case, and you have a portable instrument. You need no tools to quickly remove door for easy access or conversion from one type of display module to another.

TERMINAL BOARD AND PULL-OUT CHASSIS You can pull out the chassis to the service position without tools and without interrupting the operation of the instrument, or completely remove it. Flexible wiring drawbridge keeps instrument operating when chassis is pulled out to service position, unplugs for removal of components. All external wiring connections go to terminal board at back of instrument case.

For complete information on the *ElectroniK 17*, call your nearby Honeywell field engineer or write to MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.—In Canada, Honeywell Controls Ltd., Toronto 17, Ontario.

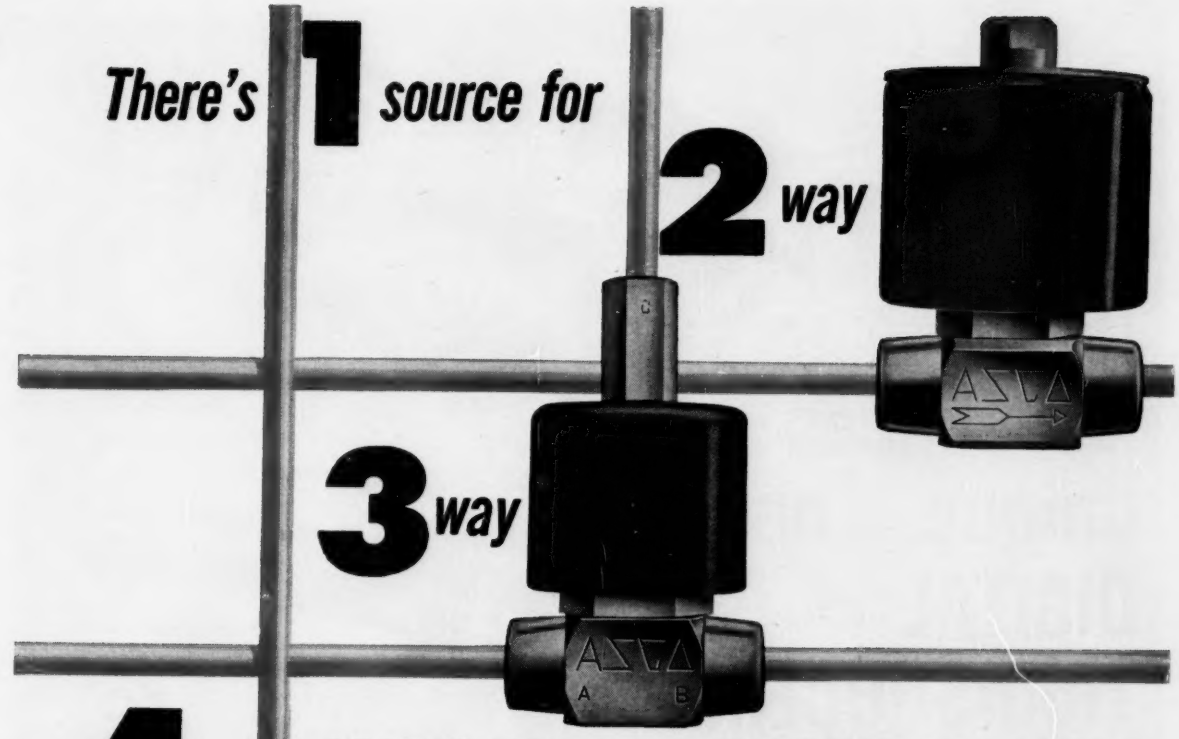
Honeywell

First in Control

SINCE 1885

PRINTED IN U.S.A. D-17-4

There's 1 source for 2 way 3 way or 4 way MIDGET SOLENOID VALVES



SHOWN ¾ ACTUAL SIZE

Progressive designers, the men who lead the trend toward miniaturization, depend on ASCO as the one source for a full line of midget solenoid valves. The unexcelled quality and dependability that ASCO pioneered in the solenoid valve field is found, too, in today's midget solenoid valves. Only the size has been reduced.

For flow applications using air, gas, water, light oil, refrigerants and many other liquids, ASCO Midget Valves assure complete safety and truly exceptional performance.

ASCO Midget Solenoid Valves are available with standard, watertight or explosion-proof enclosures. Pipe sizes ⅛" and ¼"; pressure range 0-1000 psi.

There's *one* source that solves virtually any solenoid valve problem — ASCO. Write today for complete data on ASCO Midget Solenoid Valves — or outline any of your requirements. We'll be pleased to assist you.

ASCO Valves Automatic Switch Co.

52-F HANOVER ROAD, FLORHAM PARK, NEW JERSEY, FRONTIER 7-4600

Automatic Transfer Switches • Solenoid Valves • Electromagnetic Control

ASCO®

CIRCLE 34 ON READER-SERVICE CARD

DeJUR Announces unique...new DIGITAL TRANSDUCERS and SUBMINIATURE PRESSURE INSTRUMENTS

DeJur Digital Transducers are self-contained solid state miniaturized packages designed to measure various parameters (pressure, temperature, flow, acceleration) and supply a digital signal output without the use of auxiliary equipment. The result can be a pulse duration type (PDM) digital signal whose pulse width in time is directly proportional to the amplitude of the input parameter being measured. PPM and PFM outputs also can be made available.

Constructed to meet rigorous conditions of application and exposure, DeJur Digital Transducers produce signals compatible with digital computers and electronic counters found in all military and industrial installations.

A new dimension in pressure instrumentation is created by the introduction of a complete line of subminiature pressure instruments. It includes potentiometric pressure transducers, pressure switches and pressure indicating meters with static, dynamic and environmental performance characteristics superior to larger units.

FEATURES

- Small size . . . light weight
- Completely self-contained—no auxiliary conversion equipment needed
- Accuracy equal to much larger units
- Improved environmental and dynamic performance—ideal for military applications
- Multiple outputs obtainable
- Superior reliability and versatility

WRITE FOR DETAILED INFORMATION

You're always sure with **DeJUR**
ELECTRONIC COMPONENTS

ELECTRONICS DIVISION, DeJUR-AMSCO CORPORATION, 45-01 NORTHERN BLVD., LONG ISLAND CITY 1, N. Y.

SEE THEM AT DeJUR BOOTHS 2307-2309, I.R.E. SHOW

CIRCLE 7 ON READER-SERVICE CARD

HOKE Flow Sheet 4

HOKE REPORTS ON FLUID CONTROL

HOW TO SWITCH PRESSURES IN MID-STREAM

PRESSURE BY THE POUND . . . no matter how thin you slice it!

One trouble with doing something better is that it's hard to stop. This time, we've come up with a new line of pressure regulators. We made them for the technically oriented who have developed high standards and for the penurious purchaser who wants something for (almost) nothing.

One, tagged as the 680 Series, is a highly stable single stage regulator with something for just about everyone. The core of this regulator is its control accuracy of 2% at flows to 2000 SCFH. Two models are available. One delivers 0 to 40 psi and the other 0 to 140 psi and both can handle inlet pressures up to 3000 psi. Use them on any gas compatible with 2024-T4 aluminum alloy, neoprene, polyurethane and Buna-N.

If what we've said sounds good so far, but still won't solve your problems, read on.

We've built a regulator specially for corrosive gases and atmospheres. Available in either all monel or all stainless steel construction, we call it the 640 Series. Spec sheets on this can be had by marking an "X" below.

If you "X" the next box, you'll get a package of useful information on a special regulator that will handle delivery pressures up to 4500 psi with very high control accuracy. This is a 2 stage spring and dome loaded regulator and we claim that a 50% change in inlet pressure will not change the delivery pressure more than 2%. Operation is simplicity itself. For no particular reason, we call this the 920 Series.

Skeptics should send for all of this information.

For reasons now hidden by the veil of tradition, no one has ever attempted to scrunch a pressure switch to its proper proportions—that is, until now. With sales getting bigger from making things smaller, we decided that this was the path to profit. Ergo; the new Hoke Pamar pressure switch.

This isn't just a case of arrested development, but something entirely new. The scrunching process necessitated less parts, so conventional connecting linkages were the first to go. The direct result: a switch with only one moving part—nothing to wear and upset the actuation setting.

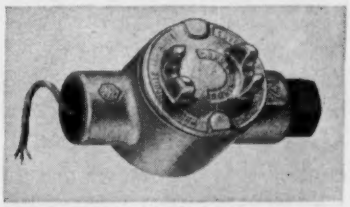
The ordinary bellows was out of the question, so we used a Ni Span C capsular type sensing element. Out of this came such things as high repeatability, minimum hysteresis and drift, maximum temperature stability, and a dead-band of minor significance.

The whole assembly measures less than 2 inches from tip to terminals, and weighs short of one ounce. Despite these diminutive dimensions, it is capable of handling working pressures to 500 psi with a repeatable accuracy of ±0.5%. Electrically, it sports a snap-action switch that will conduct a current of up to 7 amps to a variety of connectors – AN, cabled leads, solder terminals, or whatever you want. Interested in pressure switches for explosive atmospheres? Specify the explosion-proof model.

A special low pressure switch (0 to 7 psi) defies competition with a dead band of 2" of water!

If what you're looking for in a pressure switch seems impossible to find (even with the wonders we've described here), we'd like to hear about it. We thrive on doing what others shrink from, and will build a switch to your specs. Write and tell us your problem.

We could go on, but that wouldn't leave us with the usual advertising "hooker". We want to hear from you. In return, we'll send you the rest of the story.



WHAT'S NEW FROM HOKE?

Lots of things have been happening at Hoke. To be sure you're up to date on these developments in fluid control see your nearest distributor. He'll have something new for you every other month this year.

Hoke's Performance Guarantee—*Every Valve Leak-Tested!*

HOKE INCORPORATED
31 Piermont Road, Cresskill, N. J.

Send me complete information on the Hoke products checked below:

- ☐ Pamar Pressure Switches
- ☐ 680 Series Regulator
- ☐ 640 Series Regulator
- ☐ 920 Series Regulator
- ☐ "What's New"

NAME_____ TITLE_____

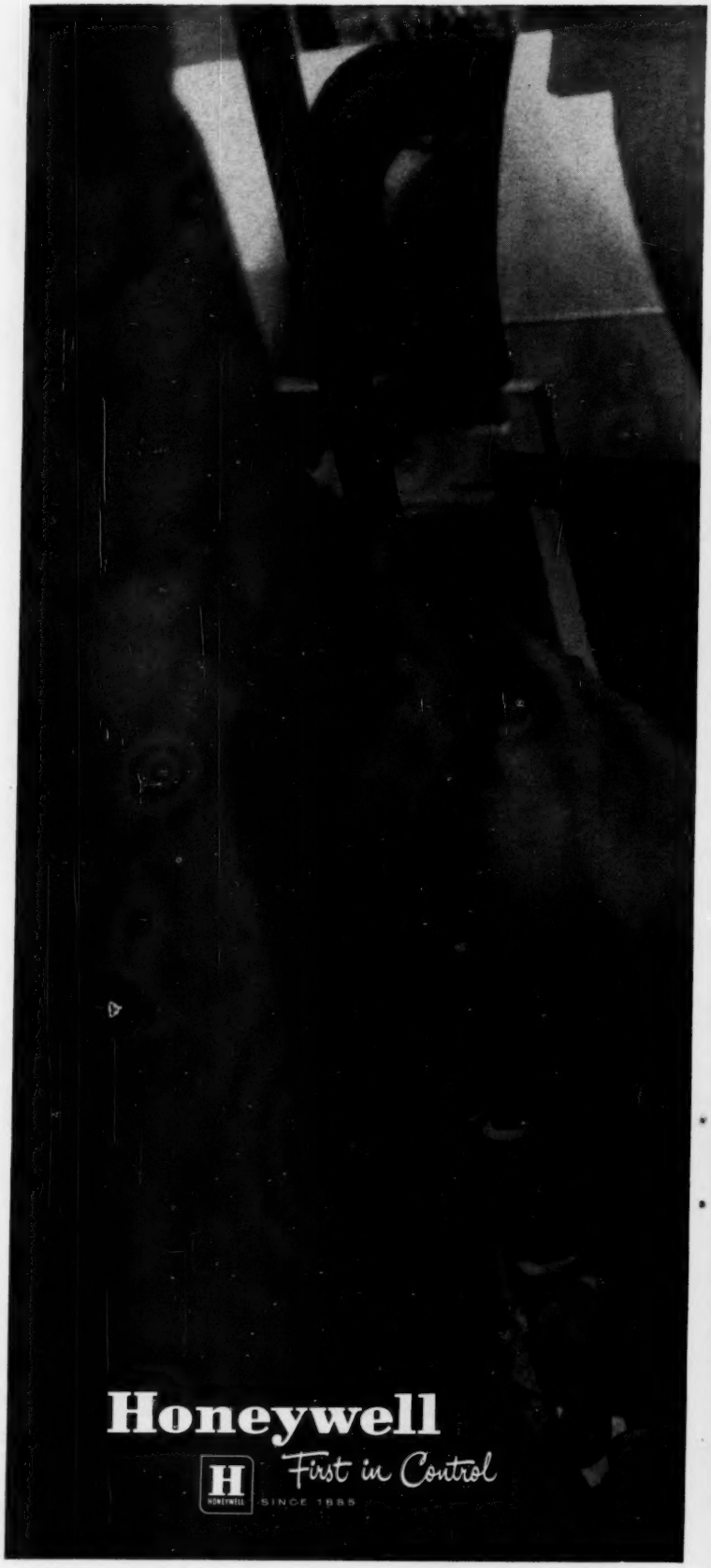
COMPANY_____

ADDRESS_____

CITY_____ STATE_____

SEE OUR CATALOG IN SWEETS PRODUCT DESIGN FILE

CIRCLE 8 ON READER-SERVICE CARD



The Honeywell Control Valve (foreground) regulates flow of Bunker C fuel oil burner in a chemical process drying system. In the background, a Honeywell diaphragm actuator operates a damper for control of hot air return. Nothing spectacular going on here, but the results of the entire process could well depend on these valves.

The final results—the payoff of the process—are dependent not just on how well these valves are made, not just on their capacity or sensitivity, but on *all* of these things combined . . . plus the process control knowledge that first put them to work, and the know-how that keeps them on the job.

Here, as in all Honeywell Control Valve applications, *every* aspect of valve performance has been considered in relation to the overall control system. It is this "whole picture" approach that sets Honeywell Control Valves apart, and rewards you with better processing.

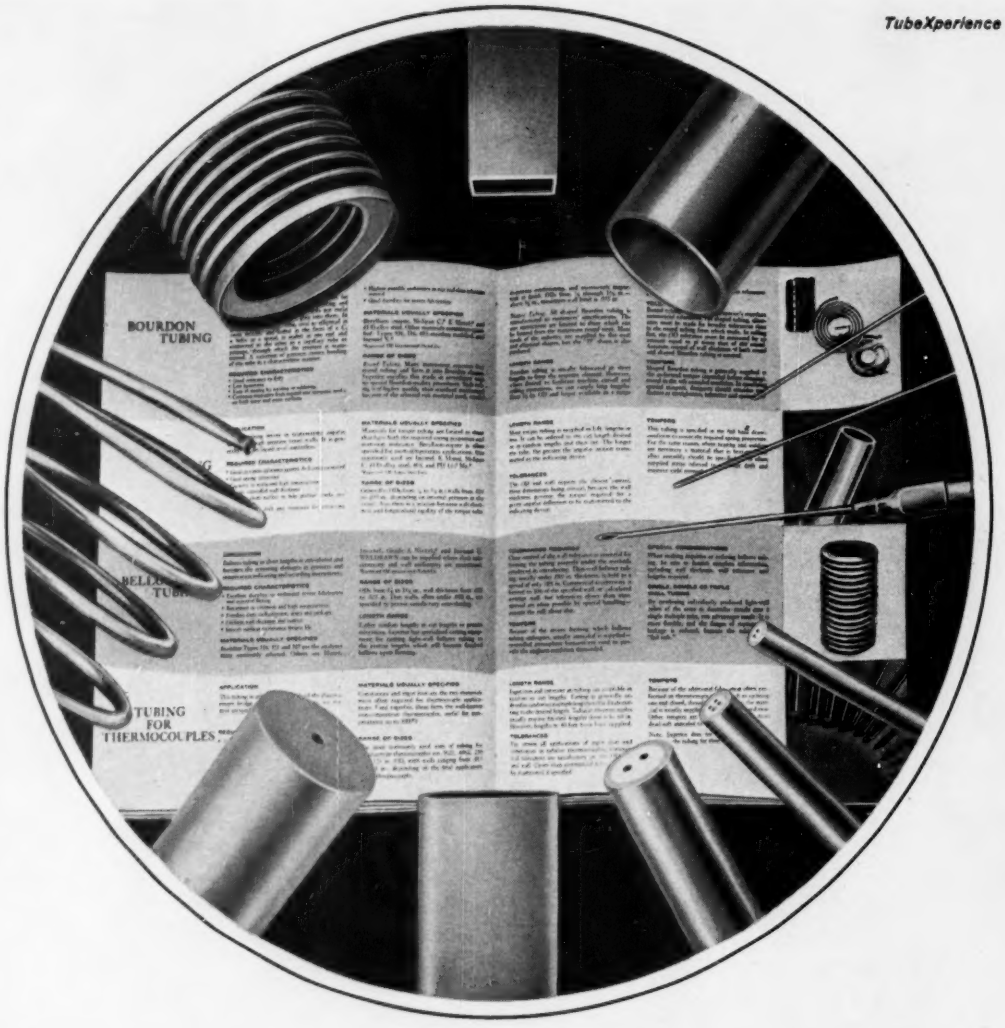
Write today for your copy of our checklist, "25 Ways to Be Right" . . . in selecting control valves.

MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.

HONEYWELL INTERNATIONAL
Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

Photographed at Davison Chemical Company, a division of W. R. Grace & Company.

CIRCLE 36 ON READER-SERVICE CARD



TUBEXPERIENCE PREPARES A NEW INSTRUMENT BULLETIN —GUIDE TO SELECTION AND APPLICATION OF INSTRUMENT TUBING

Superior's long experience in producing small-diameter metal tubing to extremely close tolerances enables it to offer instrument designers and makers a wide variety of materials, sizes, metallurgical competence, and manufacturing skills that save experimentation in the design stage . . . time and cost in production.

"Specialty Tubing for Industrial Instrumentation"—a new bulletin by Superior just off the press—puts into print for the first time comprehensive information that covers all types of Superior tubing for the instrument field. It includes required characteristics, materials usually specified, range of sizes, tolerances, tempers, and special considerations for thermometer-bulb, capillary, Bourdon, bellows, fire detection, linkage, recording-pen and torque tubing; also tubing for thermocouples and gas chromatography.

Send for a copy of this valuable bulletin today. The information covered will greatly help your selection of tubing for all measuring, indicating, recording and control devices. If you have a problem involving tubing, call on us to help you solve it. Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

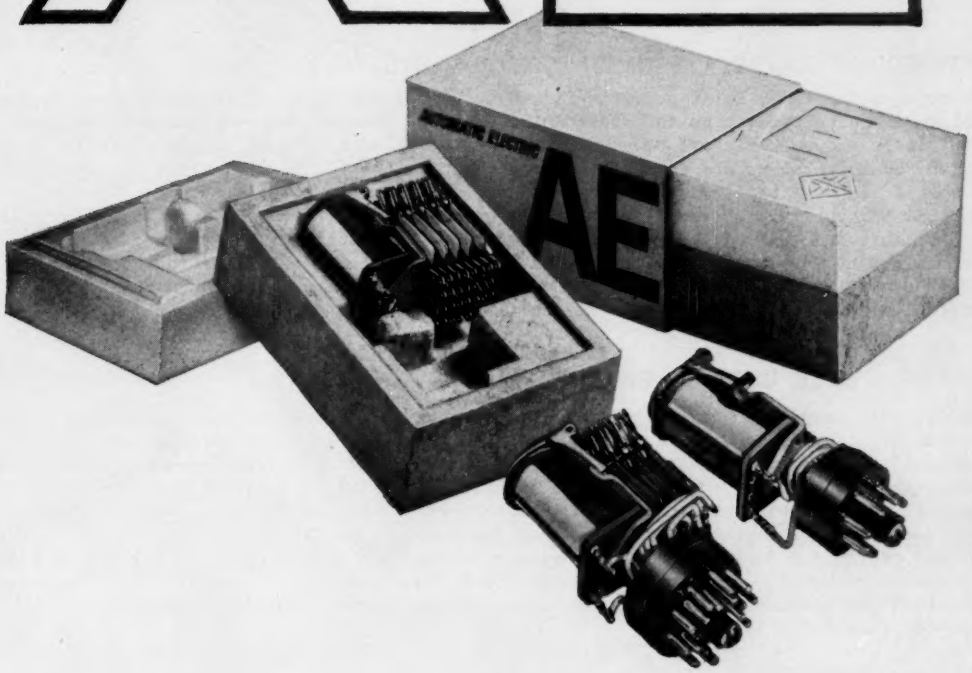
NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

CIRCLE 37 ON READER-SERVICE CARD

AE



TO THE ENGINEER
who wants his "circuit jewelry" intact

AE takes great pains in preparing its Class E relays for a well-adjusted life in the world of automatic control. To make sure that they reach you in the same happy state, we're now shipping them in a special protective package molded to shape from featherweight polystyrene foam.

The two sections of the case have identical multiform cavities. When put together, they form a snug fit for any Class E relay assembly. The possibility of relay damage in packing, in transit or in removal is virtually eliminated. To facilitate production, the containers can be fed directly to your assembly line; relays remain protected and accessible.

As for Class E relays, you can have them with the usual solder terminals, "Taper-Tabs," end-mounted printed circuit terminals, wire-wrap, prewired octal plugs, screw terminals or other special forms to fit your needs.

Our circuit engineers will be happy to work with you in applying Class E relays to your designs. They'll also be glad to tackle any control problems you may have.

Want details? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. And be sure to ask for Circular 1702-E, "Relays for Industry."

AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

CIRCLE 38 ON READER-SERVICE CARD

HAGAN NEWSLETTER—MARCH

Behind the panel

HAGAN POWRMAG® MAKES A "SWEET" CONTROL SYSTEM

In sugar refineries, moist sugar is fed to the upper end of a rotary dryer-granulator so that moisture can be removed as the sugar is granulated. The sugar is discharged into dry sugar containers and control must be accurate to avoid caking or burning of the finished product. Hagan PowrMag systems are doing this "sweet" job in two plants of a major refiner. Drying is accomplished by a blast of warm air from a constant speed blower. Setpoint temperature is maintained by varying steam flow to a heat exchanger over which the air flows. Both air temperature and sugar temperature are measured by resistance bulbs, and sugar temperature is maintained by varying the set point of the air temperature controller in accordance with any error signal from the sugar temperature recorder. A total of nine such systems are in operation. (Details on request. Ask for Item P-1.)

TEMPERATURE RISE USED TO PROTECT $125,000 PUMP

Boiler feed pumps for a big utility boiler come high. At one station, generating 1,800,000 pounds of steam per hour, there are three such pumps. When flows through these pumps are low, internal temperature rise increases and the pump can easily be destroyed. Conventional recirculation systems use feedwater flow as a criterion, but this does not provide protection against heating which may occur even though flows are beyond the usual danger point. Hagan systems use temperature difference across the pumps to establish control. Taking a thermocouple signal of about 0.6 mv, the Hagan PowrAmp amplifies the signal, puts it through an electro-pneumatic converter, and provides fast and accurate operation of recirculation valves. Result: positive protection for expensive, hard-to-replace pumps. (Details on request. Ask for Item P-2.)

SIMPLIFIED AIR CONDITIONING BOOKKEEPING--WITH HAGAN RING BALANCE METERS

Comfort cooling for a complex of office buildings and shops takes big equipment. At one such location, where Hagan Ring Balance-PowrLog meters keep tab on the system, capacity is rated at 7500 tons. In this installation, chilled water flow, outgoing and returning chilled water temperature difference, and total Btu load are recorded in a single meter case. In addition, Btu load is computed and totalized on the integrator. Totalizing is in "Therms" for easy reading and bookkeeping. Since the metered totals are used in billing the amount of cooling supplied to each user, figures must be accurate. Management chose Hagan Ring Balance for this service because of its superior accuracy, reliability and the ease with which calibration can be checked. (Details on request. Ask for Item P-3.)

150-FOOT PHOSPHATE KILN TO HAVE HAGAN POWRMAG CONTROLS

Complete controls for a 150-foot phosphate nodulizing kiln are being provided by Hagan. The basic system will be PowrMag (magnetic amplifier) with Hagan Pneumatic Power Positioners for final control actions. Included in the system are control of: kiln hood pressure, cooler grate speed, fuel/air ratio and combustion air temperature, cooler temperature and kiln temperature. In all, there are more than twenty sub-systems, including pH control of the clarifier, oxygen content of combustion gases, kiln speed and material feed rate. All of these systems are tied together so that optimum production may be expected from the kiln. Hagan PowrMag controls were chosen because they offer accurate, trouble-free operation and minimum maintenance. (Details on request. Ask for Item P-4.)

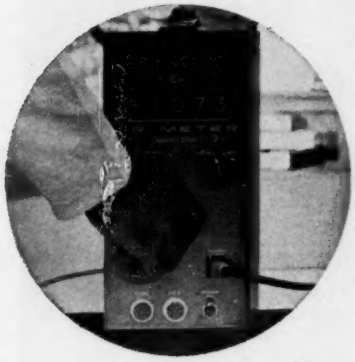
HAGAN CHEMICALS & CONTROLS, INC., Hagan Center, Room 715, Pittsburgh 30, Pa.

HAGAN DIVISIONS: CALGON CO. — HALL LABORATORIES — BRUNER CORP.

CIRCLE 39 ON READER-SERVICE CARD

THIS DVM IS EXPLOSION PROOF!

Cubic announces the first digital voltmeter that may be used in any explosive atmosphere. The new Model 2100 is ideal for use around aircraft or missiles that are being fueled, in pipeline pumping stations, refineries, chemical processing plants, munitions factories and all other environments formerly considered "off-limits" for a DVM. It has already been chosen for use on Polaris-armed submarines.



Other Features of the Model 2100: shockproof—withstands up to 50G shock; waterproof—can operate underwater; corrosion-proof—can't be damaged by salt spray or chemicals; specifications equal or exceed those of all high performance meters. Write for descriptive literature to Dept. IC-102, Industrial Division, Cubic Corporation, San Diego 11, Calif.

Visit us at the I.R.E. Show... Booth No. 3111

Cubic manufactures a complete line of quality digital instruments, including a-c and d-c voltmeters, ohmmeters, ratiometers, scanners and printer controls.

cubic
CORPORATION

CIRCLE 40 ON READER-SERVICE CARD

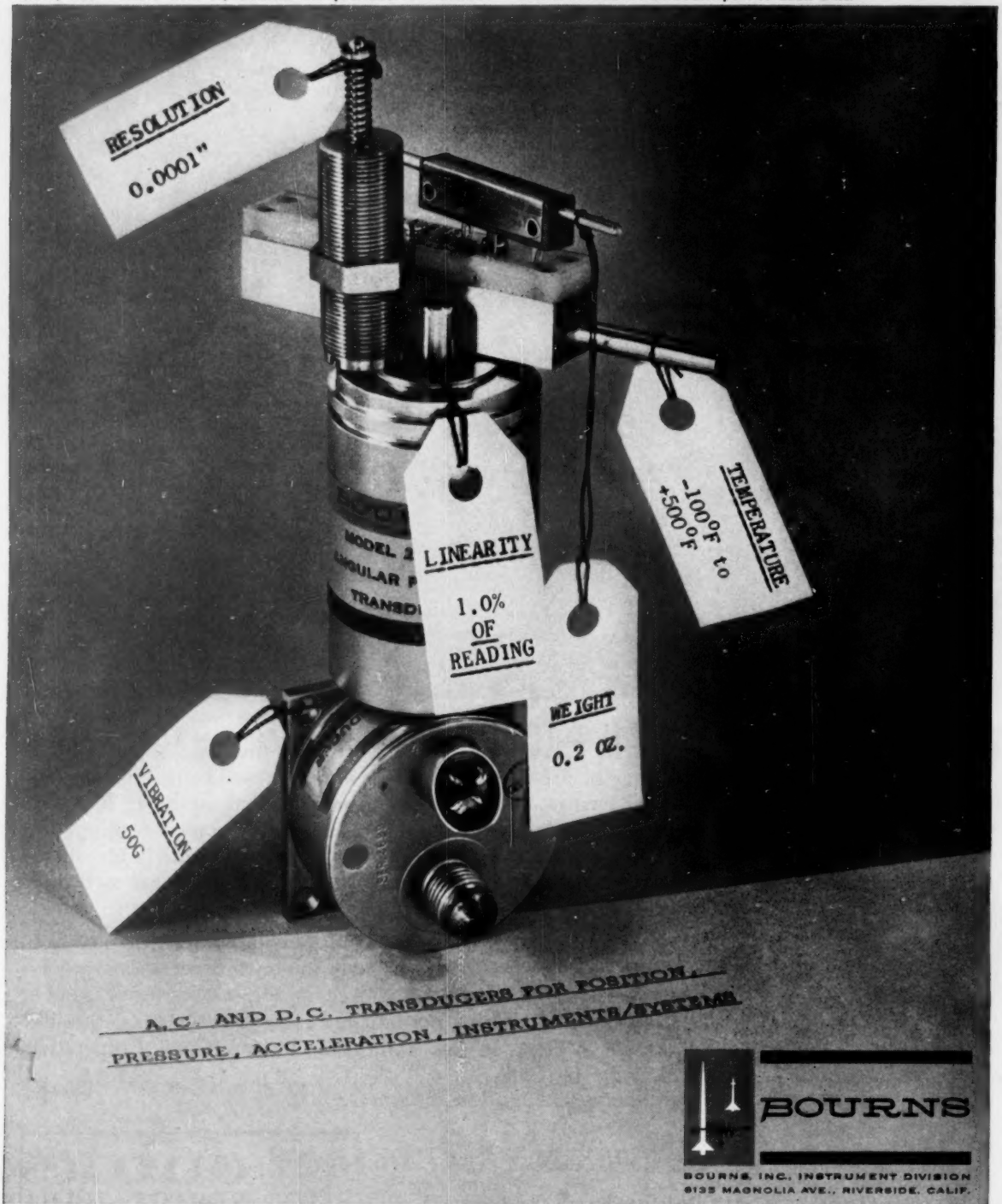
See us March 20-23 at the IRE Show/Booths 1816-1818.

NUMBER 11—INSTRUMENT SERIES

Bourns Transducers –Tagged Tops in Every Spec!

In every measurement of transducer performance, Bourns offers you the top figure. If you're looking for the ideal combination of characteristics, it stands to reason that you'll get it from the company that has attained the highest performance in individual parameters. There may never be an "ideal" transducer; but if there ever is, Bourns will produce it—because Bourns is closest today.

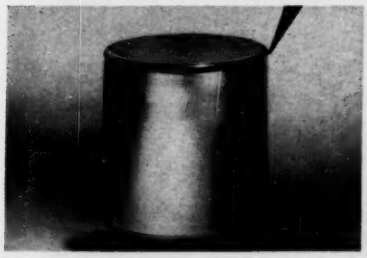
Bourns offers you proven transducers for position, pressure and acceleration. Their reliability is a reality, written in the record of virtually every major U.S. missile and space program, and documented for you in the detailed certificate of inspection and calibration that accompanies each unit.



Pioneers in transducers for position, pressure and acceleration. Exclusive designers and manufacturers of Trimpot® potentiometers.

CIRCLE 41 ON READER-SERVICE CARD

AIRBORNE DC AMPLIFIER



Small, solid state, direct-coupled DC amplifier weighs only six ounces. Less than five cubic inches in volume, this rugged, hermetically sealed instrument is available with solder, plug-in, coax or combination header arrangements and a variety of mountings. DC gain is 200 to 1000 ±0.75%. Input capability is 5 millivolts differential at maximum gain; output capability is ±5 volts into not less than 20K (single-ended). Companion power supply also available.—*Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif.*

CIRCLE 42 ON READER-SERVICE CARD

WELDABLE STRAIN GAGE

Precise, rugged gage is capable of continuous operation at 750°F and dynamic test to 1500°F. These gages employ one-piece etched wire filaments in swaged stainless steel tubes, and are suitable for use from cryogenic to elevated temperatures. They are also available with inherent temperature compensation (no dummy gages required). Easy installation through the use of stored-energy welding equipment eliminates complicated bonding and curing processes. Also available in integral lead strain gage versions.—*Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif.*

CIRCLE 43 ON READER-SERVICE CARD

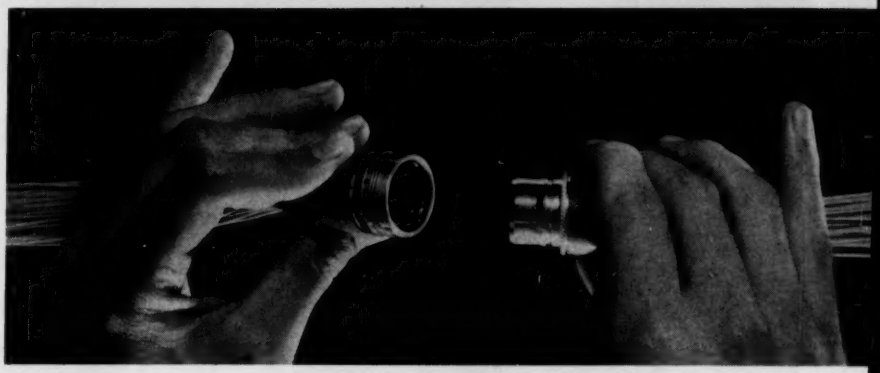
HARDWARE CATALOG

Comprehensive 32-page catalog of Lerco hardware products contains over 380 standard part numbers; specifications and ordering information for terminals, terminal boards, eyelets, stand-offs, shaft locks and miscellaneous hardware; handles and control knobs; custom engineering facilities.—*Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif.*

CIRCLE 44 ON READER-SERVICE CARD

CIRCLE 45 ON READER-SERVICE CARD ⟶

MICROMINIATURE MULTI-PIN CONNECTORS



Visualize 61 contacts in the diameter of a dime... think of slashing connector weight requirements by 33%... estimate the dollar savings in time and inventory of a connector with complete interchangeability of parts. This unique combination of advantages—and more—are built-in features of Microdot's new multi-pins.

In airborne and ground support applications where size, weight and reliability are vital factors, Microdot's unique new multi-pin connector stands alone. Available in three shell sizes and a variety of mounting versions, these rugged connectors are adaptable to a wide range of specific applications (you specify from a wide variety of standard, interchangeable multi-pin component parts to arrive at a connector tailored to your specific application).

Inserts are available in a variety of straight power, straight coaxial, and power-coaxial layouts. Power contacts are interchangeable without changing inserts, allowing hermaphroditic contact arrangements (a mixture of male and female contacts within the same plug or receptacle, allowing hot leads to both plug and receptacle). Closed entry, pure coin silver socket contacts allow heavy currents with low temperature rise. Contact resistance is almost nil. Write today for detailed descriptive literature, Bulletin MP-O.

SIZE DESIGNATION	PLUG O.D.	NO. OF COAXIAL CONTACTS	NO. OF POWER CONTACTS
A	⅝"	up to 7	up to 19
B	⅞"	up to 12	up to 37
C	1¼"	up to 19	up to 61

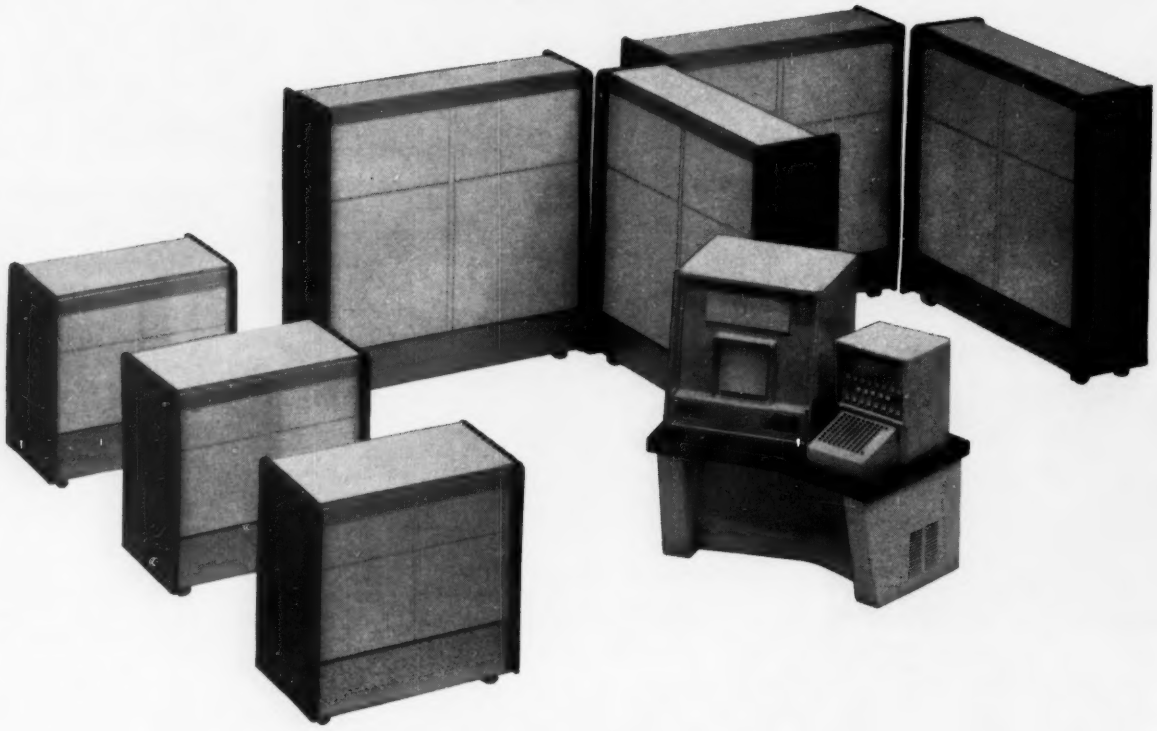
Microdot Multi-Pins are available in disassembled "kit" form or, if you prefer, factory assembled with Microdot cable.

MICRODOT INC.

220 Pasadena Avenue, South Pasadena, Calif.

MUrray 2-3351 SYcamore 9-9171

LFE's new RD-900 system--



. . . provides a random access file of up to 495 million bits with access to information in less than 3/10 of a second.

. . . may be operated with all standard general purpose digital computers, or as an independent storage, access and display system.

The RD-900 Random Access Storage and Display System, consists of from 1 to 33 high density, magnetic, file drums, each with a storage capacity of 15 million bits. A Symbol Generator converts coded characters into a visual message as fast as they are read from the file. One Symbol Generator is used to drive any number of output display devices. These include 21″ console displays and large screen projection displays . . . each capable of displaying up to 12,800 characters, symbols or a composite of both. In addition to alphanumeric characters the system can display arbitrary or abstract symbols, schematic or logical drawings, graphs, charts, and maps. Applications include military and industrial systems where information retrieval and display must be simultaneous for instant decision making. For a complete description and specifications write Dept. 101.

LFE
COMPUTER PRODUCTS DIVISION

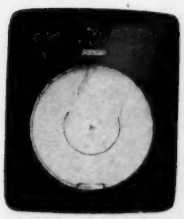
LABORATORY FOR ELECTRONICS, INC.

1079 COMMONWEALTH AVE. • BOSTON 15, MASSACHUSETTS

CIRCLE 46 ON READER-SERVICE CARD

Foxboro eliminates the amplifier from pH recording and control

cuts the drift, cuts the cost, cuts the maintenance, too!



Foxboro pH Dynalog Controller — for use where it is desired to hold pH at a predetermined value.

Foxboro pH Dynalog Indicator — for use where complete record of pH value is not required.

THAT'S RIGHT — the intermediate amplifier is gone from Foxboro's new low-cost system for measuring pH. And gone with it is the wasted panel space, the drift, the daily standardization inherent with earlier systems.

In the new Foxboro system, the signal from the pH electrode goes direct to a high impedance Dynalog* receiver — without intermediate amplification. Signal operates a direct-reading indicator or recorder — or a controller and alarms, when desired.

The new Foxboro pH system is the simplest, most economical method of measuring pH available today. Ask your Foxboro Field Engineer to tell you about it. Or write for data sheet. The Foxboro Company, 463 Neponset Avenue, Foxboro, Massachusetts.

*Reg. U.S. Pat. Off.

FOXBORO Analytical Instrumentation

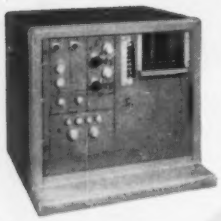
REG. U. S. PAT. OFF.

CIRCLE 47 ON READER-SERVICE CARD

The Offner Type R All Transistor Dynograph

provides greatest versatility

NEW
2 Channel DYNOGRAPH
see it at the IRE Show . . . Booth 3051

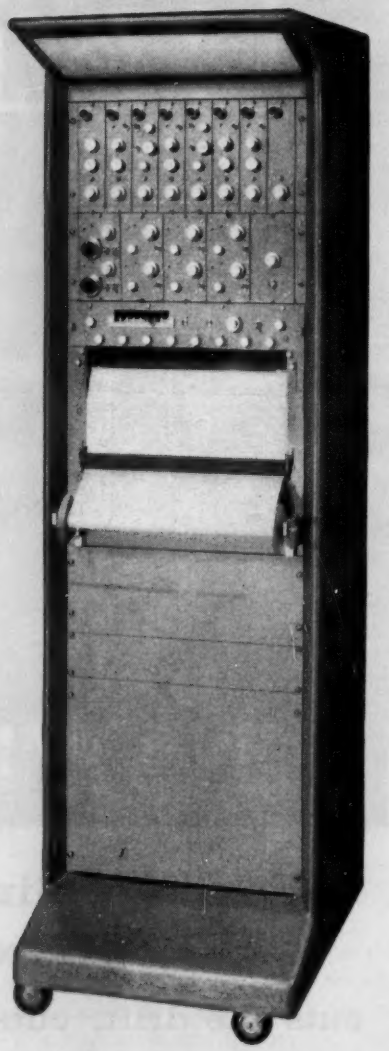


RP TWO CHANNEL
Compact, economical, convenient where only one or two channels are desired.

BMM/B CONSOLE
Features horizontal paper travel. Available as Type R or RC.

R SIXTEEN CHANNEL
Assemblies with 16 channels, 24 inch paper permits up to 24 channels on one inch centers.

RC DESK-TYPE CONSOLE
Medium gain assembly for computer write-out, telemetering, applications with input signal above 10 millivolts.



Write on your company letterhead for Bulletin 891, a 20 page, 2 color brochure giving you complete specifications, application data, etc.

VERSATILITY of assemblies—select the mounting best suited for your use.

VERSATILITY of application—one set of amplifiers covers all uses, microvolt to volts dc or ac, strain gages, reluctance gages, etc.

VERSATILITY of writing media—use ink, heat, electric interchangeably on one assembly—select the one most suited for the application.

The Offner Type R Dynograph Assembly is unmatched for sensitivity, accuracy, versatility—we invite you to compare it with any other high speed direct writing oscillograph.

OFFNER ELECTRONICS INC.
3910 River Road, Schiller Park, Illinois (Suburb of Chicago)

CIRCLE 48 ON READER-SERVICE CARD

Overseas oppportunities have resulted in 3000 American companies investing some $50 billion in foreign manufacturing and marketing, says Don G. Mitchell of Gen Tel and Electronics Corp. Sales from overseas operations will at least double in the next ten years. U. S. private investment is climbing steadily in Western Europe, and today it is up around $5 billion, which is three times the total of ten years ago. American manufacturers are putting nearly 50% of their overseas capital expenditure in Europe. Western Europe has total output of goods and services equal to 60% of U. S. total.

Rotameter sales in 1960 were approximately $14 million, says Seymour Blechman, VP, Brooks Instrument Co. International market is about $20 million per year, and expanding at a rate of 15% per year.

BSDA reports that sales of scientific and industrial instruments will "increase in 1961 substantially over the $4.5 billion estimate for 1960." Reasons given include (1) proportion of capital expenditures by industry and utilities will rise from 69% in 1960 to 80% in 1961, even though level will remain constant at $20 billion, (2) process industries are spending more on expansion and modernization in 1961 than in 1960.

Industry-wide volume of leasing has gone well over $400-million a year, and will surpass the $1-billion mark by 1965. "Industry has found that leasing is an extremely economical way to get the most modern type of machinery immediately without dipping into working capital needed for other purposes," says H. Meckler, President, Lease Plan International Corp.

Electrical Measuring Instrument Shipments—First Quarter 1960, as reported by the Business & Defense Services Administration: Shipments of electrical measuring instruments by U. S. Manufacturers during the first three months of 1960 amounted to 1,037,431 units valued at $35,213,688. This total was distributed between military and non-military shipments as follows: Military—222,972 ($13,539,734); Non-Military—814,459 ($21,673,954).

ANNUAL DOLLAR VOLUME OF INSTRUMENTS SHIPPED AS REPORTED BY THE CENSUS OF MANUFACTURES

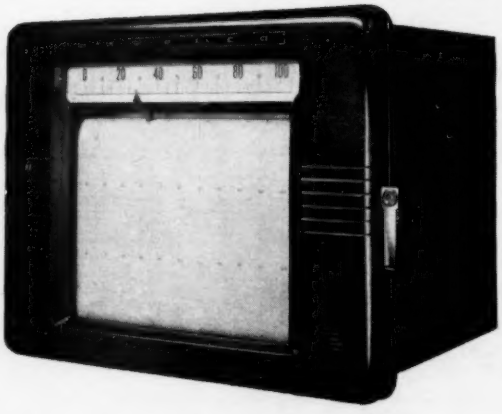
Product with Industry Code in Parenthesis	Sales in Millions of Dollars 1958	1954	1947	1939	Increase over 1939
Scales & Balances (3576)	82	59	51	14	5.8 times
Measuring & Dispensing Pumps (3586)	119	85	95	44	2.7
Electrical Measuring Instruments (3613)	643	345	157	42	15.3
Scientific Instruments (3811)	946	620	107	42	22.5
Mechanical Measuring Instruments (3821)	1061	845	425	89	11.9
Optical Measuring Instruments & Lenses (3831)	109	122	55	9	12.0
Photographic Equipment (3861)	1223	773	429	133	9.2
Watches & clocks	335	298	333	81	4.1

NEW

. . . through research by Barber-Colman

Equivalent 50-inch scale
5 *automatic* zero shifts

Automatic
Extended-Range
Recorder



Industry is offered a precise instrument to measure unknown or widely varying potentials in process control — reliably, accurately, automatically. Up to five steps of Zero suppression is equivalent to a 50-inch scale. Any basic span from 2 to 250 mv can be chosen; Zero suppression does not change span. For more details on this exciting instrument, contact any Barber-Colman, Wheelco Office — see the Yellow Pages.

BARBER COLMAN

BARBER-COLMAN COMPANY
Wheelco Industrial Instruments Division

Dept. C, 1515 Rock Street, Rockford, Illinois, U.S.A.
BARBER-COLMAN of CANADA, Ltd., Dept. C. Toronto & Montreal • Export Agent: Ad. Auriema, Inc., N.Y.

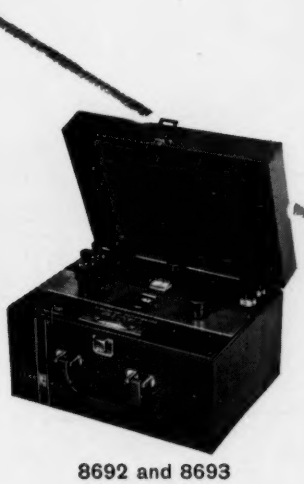
CIRCLE 49 ON READER-SERVICE CARD

Make speedier checks of recorders, controllers and base or noble metal thermocouples in industrial plants with the new three-dial 8686 Portable Millivolt Potentiometer. Features such as a central reading window . . . where measured values appear as a row of digits with a scale interpolation . . . simplify calibration of thermocouples and test measurements. The 8686 Potentiometer has: a wide operating range of −10.0 to +100.1 mv and +1010 to +1020 mv for standard cell calibration; and a high accuracy of ±(0.05% of reading +3μv) without reference junction compensation, ±(0.05% of reading + 6 μv) with ref. jct. comp. Write for Data Sheet E-33(1A).

8686 Millivolt Potentiometer

8690 Millivolt Potentiometer

Fast, accurate in-plant checking of thermocouples, recorders and controllers is expedited by the new 8690 Portable Millivolt Potentiometer. Design features such as "In-line Readout", which permit measured values to be read in digits with a scale interpolation, accelerate temperature measurements. The 8690 provides a wide range of −11.0 to +101.0 mv which eliminates input reversals; an accuracy of ±(0.05% of reading + 20 μv) without reference junction compensation, ±(0.05% of reading + 40 μv) with ref. jct. comp. Write for Data Sheet E-33(1B).



8692 and 8693 Temperature Potentiometers

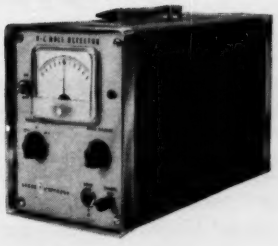
If you want to make a variety of temperature measurments quickly with one flexible instrument, investigate the new time-saving 8692 Single-Range or 8693 Double-Range Temperature Potentiometers. Available in any of 24 interchangeable temperature and millivolt ranges, these instruments read directly in degrees F or C on a scale 27½" long. Convenience features include: simplified range changes . . . only a screwdriver is needed to change a circuit panel, scale and binding post studs; automatic reference junction compensation . . . reference coil, built into circuit panel, compensates for thermocouple being used; accuracy . . . ±0.2% of range. Write for Data Sheet ND42-33(1A).

4 time-saving instruments from the

NEW

CONVENIENCE-STYLED L&N LINE . . .

Need a fast-operating, high-sensitivity, high-quality null indicator for use in research, testing and production checking? Here's a new 9834 Guarded D-C Null Detector having a short period of less than two seconds for source resistances up to 1000 ohms, increasing to 4 seconds at 100,000 ohms . . . ideal for measurements with guarded or unguarded potentiometers and bridges. Of rugged construction, this portable, line-operated detector provides numerous convenience features which include four degrees of sensitivity, with a basic sensitivity of 0.2 μv/mm (0.3 μv/scale div.), and a noise level of less than ±0.1 μv. Write for Data Sheet ED7(2).

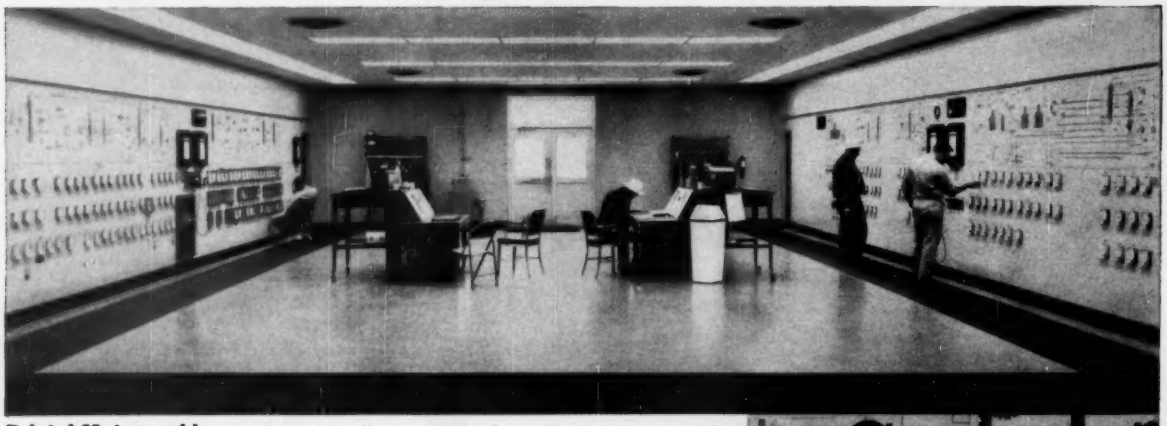


9834 Guarded D-C Null Detector

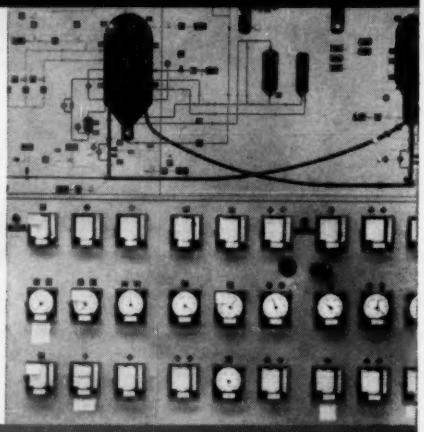
LEEDS NORTHRUP

4955 Stenton Ave., Philadelphia 44, Pa.

CIRCLE 50 ON READER-SERVICE CARD



Bristol Metagraphic recorders and indicators occupy lower three rows on panel (shown in two photos above). Enlarged panel section is shown below, right.



"NERVE CENTER" AT BIG NEW TEXACO PLANT INCLUDES BRISTOL METAGRAPHICS

This model central control room is the nerve center for a vast petroleum processing complex. It's located in the new Puget Sound Works of Texaco Inc., at Anacortes, Washington.

A key feature of the control system is a battery of several hundred Bristol Metagraphic pneumatic recorders, indicators, and controllers (lower three instrument rows on panel). The new plant produces motor gasolines, jet fuels, liquified petroleum gases (LPG), diesel fuel, furnace oil, and heavy fuel oil. Crude oil capacity is 45,000 barrels per calendar day. 0.7

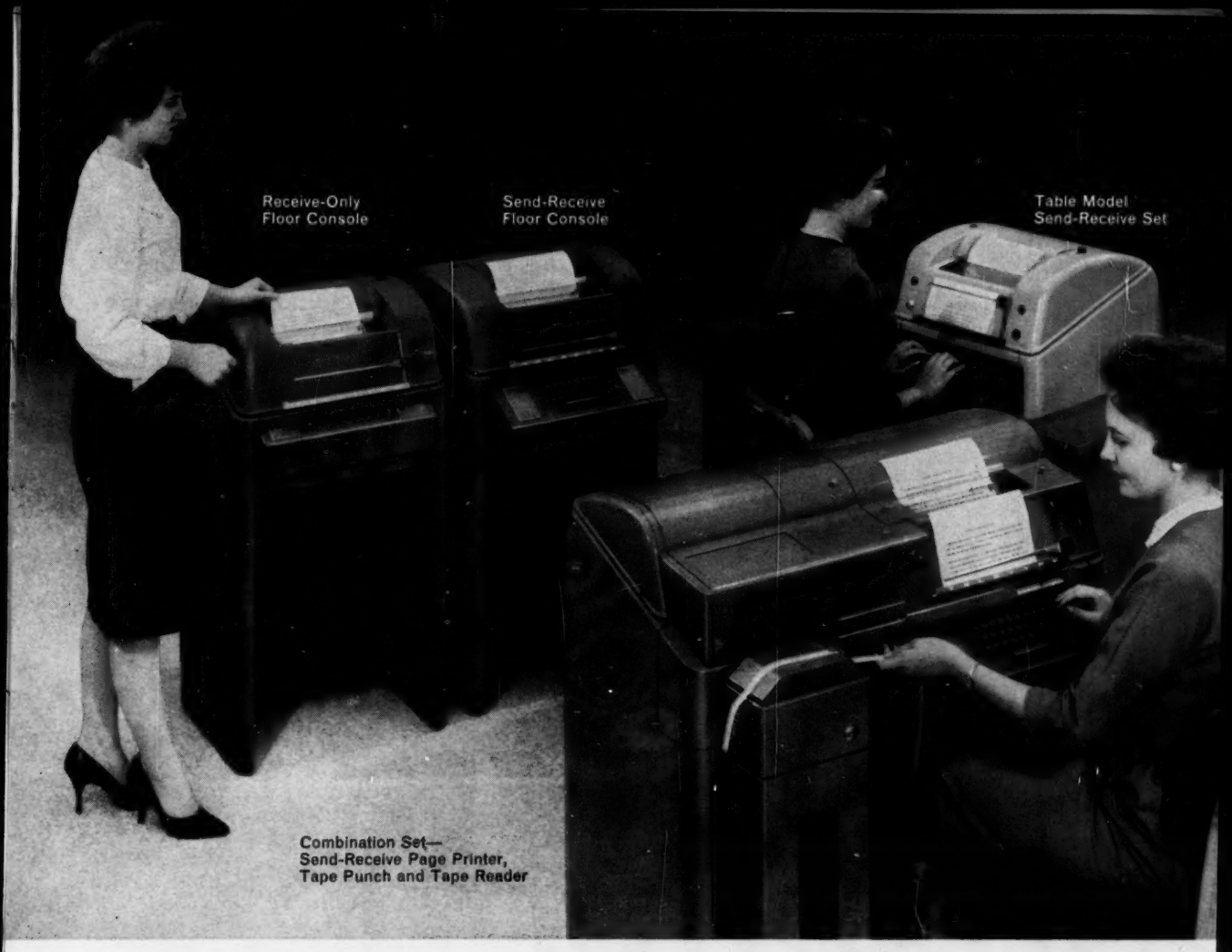
This is just one of hundreds of installations of Bristol Metagraphic instruments in use today in processing plants throughout the country. These compact instruments are ideal for graphic panel use, or where true "plug-in" versatility is necessary to insure maximum control system reliability and continuity of service. We'll be glad to send you the complete Metagraphic story. Write: The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.

BRISTOL ... for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

CIRCLE 51 ON READER-SERVICE CARD

CIRCLE 52 ON READER-SERVICE CARD ⟶



Which Teletype printer is best for you?

Which of these Teletype Model 28 page printers is best for your message and data communications needs? Each will perform the basic function of all Teletype equipment—to flash information over long or short distances. But in addition, each has varying capabilities to meet the requirements of the individual user:

Send-receive page printer in console—probably Teletype's most familiar product; for sending as well as receiving page copy.

Receive-only page printer in console—the same machine, but without a keyboard. For use where information need only be received, not sent. No operator is required.

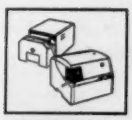
Table model—with or without keyboard . . . similar model available for rack mounting.

Combination set—a complete message center in one compact cabinet. In addition to page printer and keyboard, it contains facilities for preparing punched tape and for transmitting and receiving via tape.

All of these Teletype Model 28 page printers feature the Stunt Box, a built-in "programming" mechanism that will inexpensively handle a wide variety of remote control and switching tasks such as automatic station selection. All models can be supplied with sprocket-feed and tabulating mechanisms for use with multi-copy business forms. All are available, too, in a choice of colors to match office decor.

Teletype Corporation manufactures this equipment for the Bell System and others who require the utmost reliability from their data communications. Teletype equipment can be used with Data-Phone and other communications services.

TELETYPE®
CORPORATION • SUBSIDIARY OF *Western Electric Company* INC.


Tape Reader and Typing Tape Punch

Send-Receive Page Printer

Automatic Send-Receive Set

Free Model 28 Line folder. Write Dept. 22 C
5555 Touhy Avenue, Skokie, Illinois

accuracy

ASHCROFT DURAGAUGES measure pressure with precise accuracy no matter how severe the conditions of service

Ashcroft Duragauges are available in pressure ranges from 15 psi (or vacuum) minimum to 100,000 psi. Dial sizes: 4½" through 12".

sustained

The Bourdon tube in Ashcroft Duragauges is manufactured to precision standards of flexibility and mono-linked to the rotary movement. When pressure flexes the tube, the gauge pointer is always positively positioned, because it is mounted on the geared center shaft of the movement. Sustained high accuracy and long life are assured.

Choose your Ashcroft Duragauges made of components best suited to your needs. Eight Bourdon tube materials are available. Movement of stainless steel with nylon bearings and pinion gear for longest wear. Case materials: special aluminum alloy or tough phenol plastic.

The unique "Maxisafe®" Duragauge provides absolute protection to the viewer, plus easy and quick access to the mechanism. Your industrial supply distributor will help you select the best combination of components for your Ashcroft Gauge requirements. Phone him today or write for Catalog 300B.

MAXWELL M&M MANNING & MOORE, INC. TRADE MARK

ASHCROFT PRESSURE GAUGES

A product of

MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut

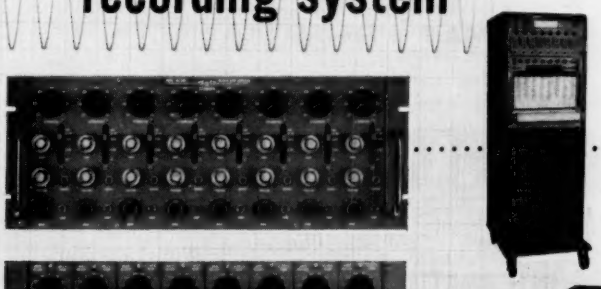
Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario
Latin America: Export Division, Chrysler Building, New York, N. Y.
Europe: Manning, Maxwell & Moore, S. A., Fribourg, Switzerland

CIRCLE 53 ON READER-SERVICE CARD

CIRCLE 54 ON READER-SERVICE CARD →

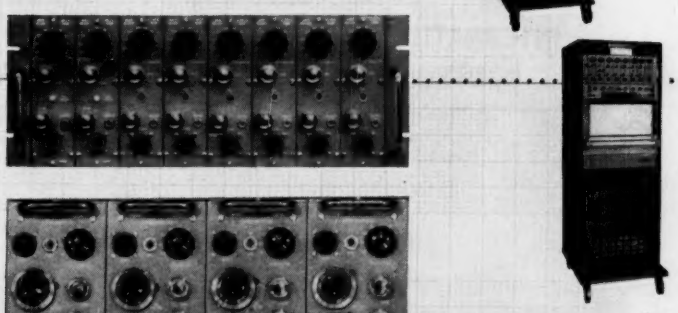
Sanborn
has probably already designed your "custom" oscillographic recording system

"Building block" recorder and amplifier design permits maximum flexibility to meet specific application needs



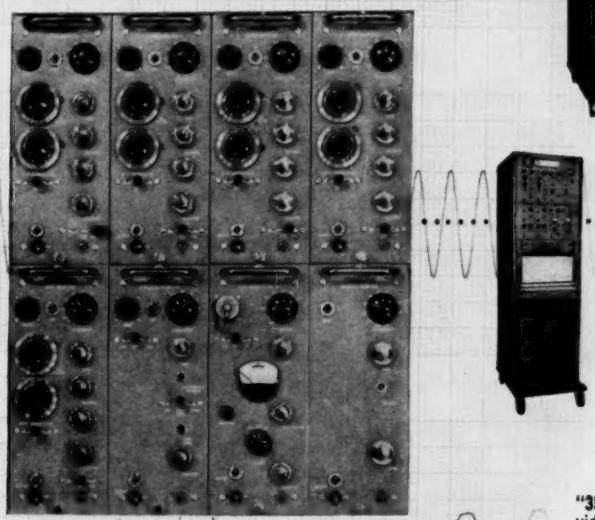
950 Series — truly low cost — identical channels

6 or 8 identical DC recording channels — either high gain, 10 uv/div; medium gain, 0.5 mv/div; or low gain, 10 mv/div. Medium and high gain types are completely transistorized, have floating and guarded input circuits. Frequency response DC to 150 cps within 3 db, 10 div peak-to-peak with low and medium gain systems, to 100 cps with high gain system. Amplifier panel space only 7" x 19", recorder 17½" x 19".



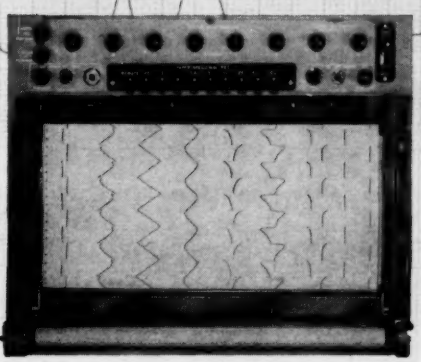
850 Series — economical, flexible — miniature plug-in preamps

Interchangeable plug-in preamps, eight to a 7" high module, available in Phase Sensitive Demodulator, DC Coupling, Carrier and Low Level types. System response to 150 cps within 3 db, 10 div peak-to-peak, depending on preamps used. Input circuits single-ended, push-pull, or floating and guarded, depending on choice of preamp.



350 Series — versatile, high performance — interchangeable preamps

Provides greatest possible application flexibility, with interchangeable preamps in Carrier, DC Coupling, Phase Sensitive Demodulator, Differential DC, Low Level, Logarithmic and Frequency Deviation types. System response DC to 150 cps within 3 db at 10 div peak-to-peak — input single-ended, floating and guarded, or push-pull — depending on preamplifier used. Eight preamps in two 4-unit modules occupy 21" x 19" of panel space; usable separately with individual power supplies to drive meters, 'scopes, etc.

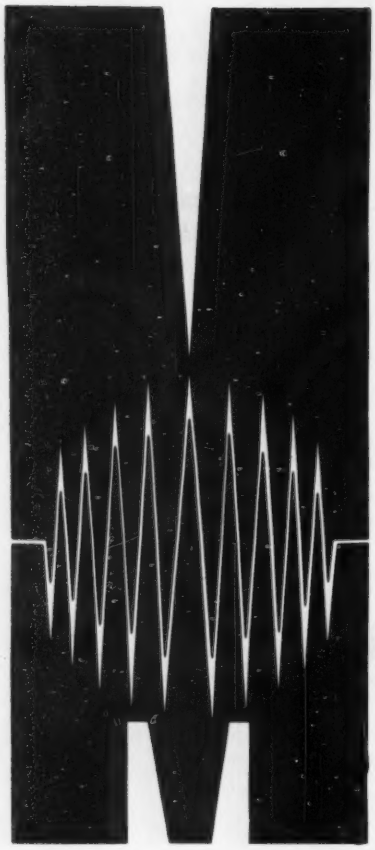


"350" style Recorder Assembly — used in all the above systems. Provides transistorized, plug-in, current-feedback power amplifiers . . . low impedance, velocity feedback damped galvanometers . . . 8" of visible record . . . 9 electrically controlled chart speeds . . . inkless traces on rectangular coordinate charts . . . flush front recorder, vertical chart plane. Recorders with horizontal chart plane also available for 350, 850 and 950 systems.

Sanborn oscillographic recording systems also include the tube-type 1- to 8-channel "150" Series with 12 plug-in preamplifiers; and the "650" 1- to 24-channel optical oscillograph with response to 5 KC and 8-channel amplifier available separately for driving any galvanometer. For complete data contact one of the Sanborn Sales-Engineering representatives located in principal cities throughout the United States, Canada and foreign countries.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman Street, Waltham 54, Massachusetts

SEE THIS EQUIPMENT AND OTHER SANBORN OSCILLOGRAPHIC RECORDING SYSTEMS, AMPLIFIERS AND TRANSDUCERS ON DISPLAY AT BOOTHS 3701-03-05, I.R.E. SHOW, NEW YORK COLISEUM, MARCH 20-23.



PARIS FROM MAY 9TH TO MAY 17TH 1961

MESUCORA

INTERNATIONAL EXHIBITION
MEASUREMENT - CONTROL - REGULATION - AUTOMATION
AND 58TH EXHIBITION OF THE
"SOCIÉTÉ FRANÇAISE DE PHYSIQUE"

- First French Exhibition exclusively devoted to these techniques, the most important and the most international one realized in Europe.
- International Congress, the subject of which will be "Recent progress in the fields of Measurement, Control and automatic Regulation, resulting from the co-operation of the Techniques (electric, electronic, mechanical)".
- 700 Exhibitors - 14 nations - 35.000 square meters.
- The most recent discoveries and appliances of the theoretic and experimental research.
- Most refined measurement and control equipments, materials and methods; their applications to regulation and automation in the fields of the industry and of the public services.
- An unprecedented gathering, an international confrontation of the highest technical value which

ALL the responsible persons in industry and the public services
ALL engineers and research workers
ALL teachers and students of the technical and scientific Upper Teaching

MUST VISIT

•

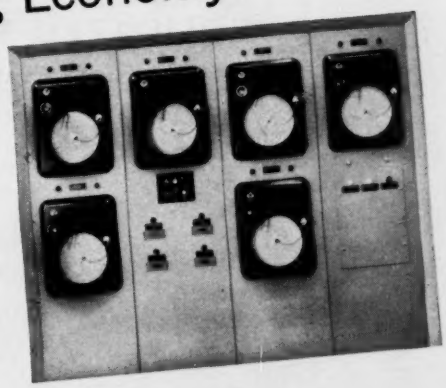
centre national des industries et des techniques

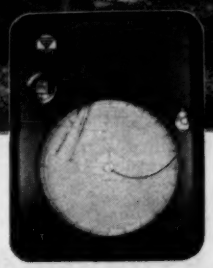
Call on : MESUCORA - Service Propagande - 40, rue du Colisée - Paris 8e - Tél. BALZAC 77-50
FRANCE for the complete documentation, stating if you want it in French, German or English.

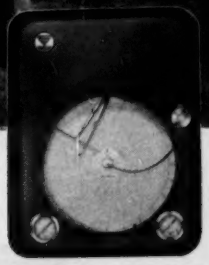
CIRCLE 55 ON READER-SERVICE CARD

American® Telemetering Equipment Means Operating Economy!

At this typical dispatching panel, one man does the work of many with American Telemetering and Telecounting equipment. At a central location, instantaneous, accurate flow and pressure readings are received from remote points and adjustments for load demands are made with remote-set controllers. Peak shaving can be performed with complete accuracy and confidence. Maximum gas sales to interruptible customers are assured.







AMERICAN®
METER COMPANY
INCORPORATED ESTABLISHED 1836

American Integrating Orifice Meters . . . Single, double and duplex-integrating models are available in a wide range of manometer types and working pressures.

American Series A-88 Controllers control flow, pressure, liquid level and other continuous process variables accurately, automatically and with a minimum of maintenance.

Whether your system is large or small, it will pay you to consult your nearest representative about the many economies American Telemetering Systems provide.

GENERAL SALES OFFICE: Philadelphia 16, Penna. • Albany • Alhambra • Atlanta Baltimore • Birmingham • Boston • Chicago • Dallas • Denver • Erie • Houston Kansas City • Los Angeles • Minneapolis • New York • Omaha • Pittsburgh • San Francisco • Seattle • Tulsa • Wynnewood

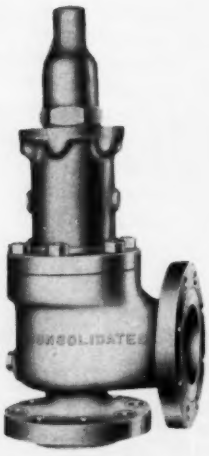
IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario • Calgary • Edmonton Montreal • Regina • Vancouver

SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminum-case, and Welded Steelcase Meters • American-Westcott Orifice Meters Instruments • Reliance Regulators • Apparatus • Valves

CIRCLE 56 ON READER-SERVICE CARD

top

CONSOLIDATED SAFETY RELIEF VALVES have a special "O" Ring Seat Seal that stops leakage completely



Consolidated Safety Relief Valves are available in both Standard and Balanced Bellows design for extreme corrosive applications.

tightness

The Seal is a resilient ring set in the valve disc. It maintains no-leak tightness by contact with a *specially curved seating surface on the valve* nozzle, yet does not carry the seat load imposed *by the valve spring.*

Tightness is maintained at *operating pressures* far closer to set pressure than with metal-to-metal seats alone. Tight closure *is as efficient* after "simmer" as on normal blowdown. Piping strains are absorbed far better by *the resilient* seal than all-metal seating. If the tough seal is ruined by entrained abrasives, *replacement is* easy. Seals are available in materials that resist corrosive fluids. Maintenance costs are greatly reduced.

Standard Consolidated Safety Relief Valves have an eductor tube that removes pressure from the *closed bonnet. Only the spring controls valve* action. You get guaranteed capacity ratings and *highest dependability—absolute protection for* personnel and equipment. Additionally, there is *the economy of converting the Standard valve to* the Balanced Bellows type in your own shop. *Get complete details. Write for Bulletin 1940.*

CONSOLIDATED SAFETY RELIEF VALVES

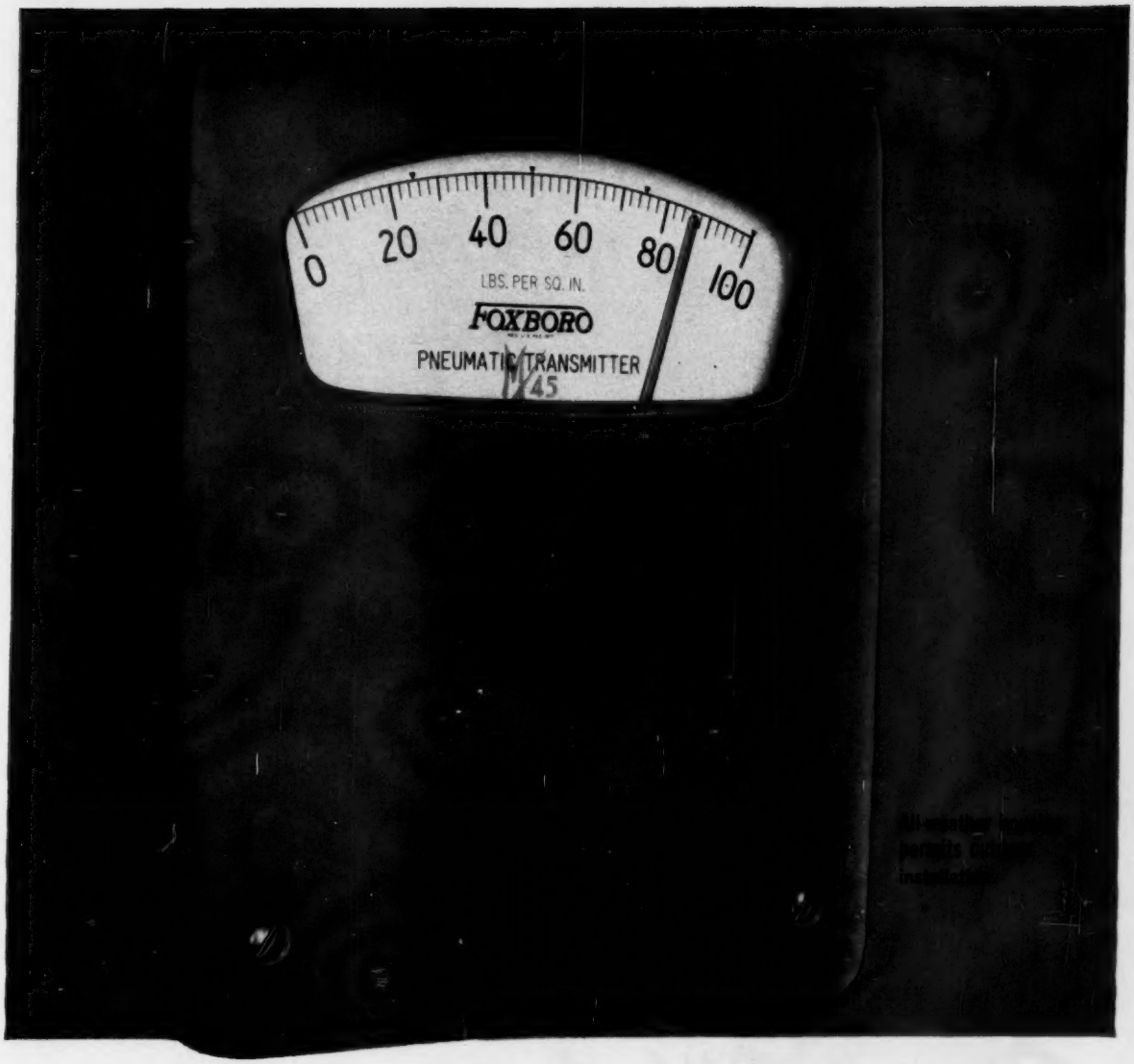
A product of

MANNING, MAXWELL & MOORE, INC.

Valve Division • Tulsa, Oklahoma

Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario
Latin America: Export Division, Chrysler Building, New York, N. Y.
Europe: Manning, Maxwell & Moore, S. A., Fribourg, Switzerland

CIRCLE 57 ON READER-SERVICE CARD



You can use this new Foxboro pneumatic transmitter on six different process measurements

pressure – temperature – liquid level – differential pressure – dew point – flow... all six with guaranteed accuracy of ±½ of 1%

Think of it . . . a universal pneumatic transmitter with matched elements for six different process variables. That's the new Foxboro M/45 pneumatic indicating transmitter.

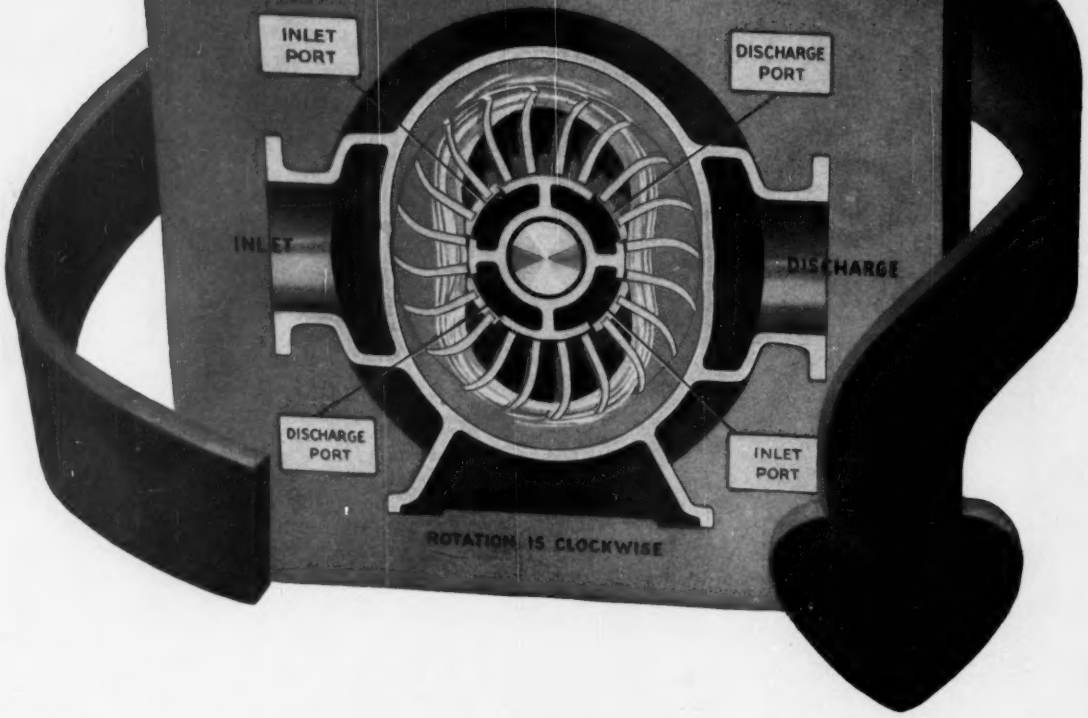
And with the M/45 you get: *universal* high accuracy-guaranteed at ±½ of 1%; *universal* ambient temperature stability — less than ½ of 1% in 50°F temperature change; *universal* calibration and simplicity of servicing. A remarkable combination of versatility and uniformity in a single instrument.

The new Foxboro M/45 indicating transmitter can extend the benefits of standardization throughout your whole plant operation. Ask your Foxboro field engineer to tell you about it. Or write for Bulletin 13-30. The Foxboro Company, 463 Neponset Ave., Foxboro, Mass.

FOXBORO
REG. U.S. PAT. OFF.

CIRCLE 58 ON READER-SERVICE CARD

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters



Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

REMEMBER COLLAR BUTTONS?

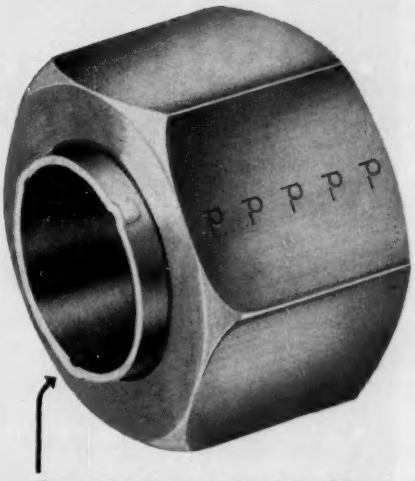
NOW **PARKER** HAS ELIMINATED A MORE SERIOUS ANNOYANCE ...LOST TUBE FITTING FERRULES!

A simple change in the design of Parker "Intru-lok®," the positive, bite-type Parker fitting for copper, aluminum or plastic tubing, has solved an age-old problem.

Small three- and four-piece tube fittings have long been a pain in the neck on applications where it is necessary to remove the nut from the fitting. The ferrule(s) fall out and promptly disappear. If and when found, they often get put in backwards. Sometimes they never get put back at all. Result, in either case: a leaking joint.

Now Parker has developed a snap-in, captive ferrule for "Intru-lok." You can take it out of the nut, "on purpose," but you can't drop it out accidentally.

You get all the leakproof safety of a three-piece fitting with positive "bite." You also get the convenience, the quick, easy assembly of a two-piece fitting. The easiest fitting to install has been made even easier. Write for new "Intru-lok" dimensions and prices today.



Three "detents" hold the "tail" of the new ferrule in the nut. Also, the larger hole in the nut makes tube bends closer to the fitting possible. Note the larger wrench flats on this huskier nut, too.

The new nut with captive ferrule is available on all "Intru-lok" fittings sizes from #2 through #8 (1/16" through 1/2" O.D.). Shown below actual size:

Parker FITTINGS AND HOSE DIVISION
17325 Euclid Avenue • Cleveland 12, Ohio
PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS
EUROPEAN DIVISION • PARKER-HANNIFIN N.V. • SCHIPHOL • THE NETHERLANDS

8278-PH

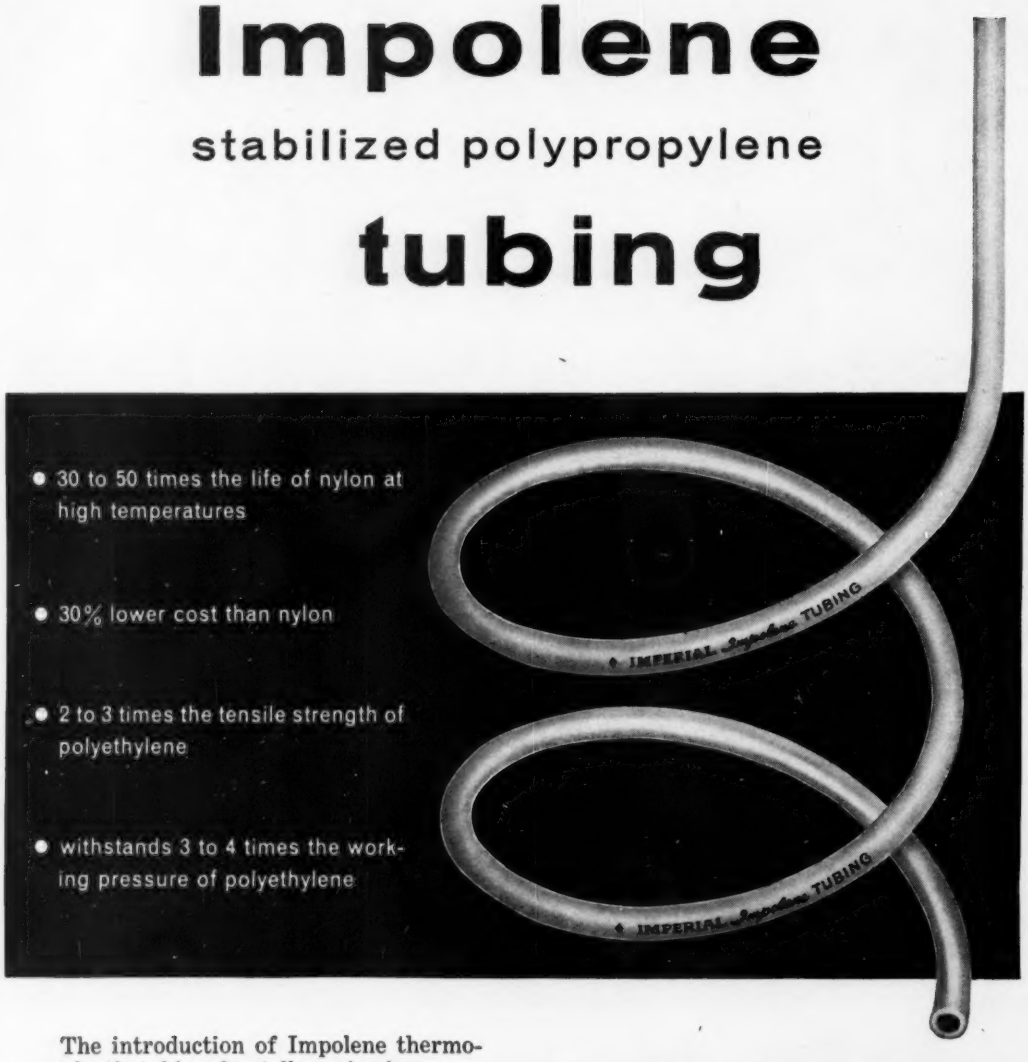
CIRCLE 59 ON READER-SERVICE CARD

new

Impolene

stabilized polypropylene

tubing


• 30 to 50 times the life of nylon at high temperatures
• 30% lower cost than nylon
• 2 to 3 times the tensile strength of polyethylene
• withstands 3 to 4 times the working pressure of polyethylene
IMPERIAL Impolene TUBING
IMPERIAL Impolene TUBING

The introduction of Impolene thermoplastic tubing foretells major improvements in the transmission of air and fluids. This Imperial-Eastman stabilized polypropylene tubing now has many proved uses. Many more await it. What's yours? For complete data, write for Impolene Bulletin No. 301.

IMPOLENE

IMPERIAL EASTMAN

Imperial-Eastman Corporation General Offices: 6300 West Howard Street, Chicago 48, Illinois

In Canada: Imperial-Eastman Corporation (Canada) Ltd., P.O. Box 645, Barrie, Ontario

CIRCLE 71 ON READER-SERVICE CARD

new Impolene

with *new* advantages, many *new* uses

High tensile strength. Highest strength-to-weight ratio of all thermoplastic tubing. Working pressures compare favorably with nylon—are 3 to 4 times greater than polyethylene.

Excellent corrosion-resistance. Resists concentrated hydrochloric acid up to the boiling point. Withstands saline solutions at temperatures over 212° F. Shows no detrimental effects in boiling sulfuric acid.

Wide temperature range. Can be used up to 300° F. Has 30 to 50 times the life of nylon at elevated temperatures. Remains flexible at −100° F.

Good abrasion-resistance. High surface hardness gives it much better abrasion-resistance than most thermoplastics.

Odorless . . . tasteless . . . resists sunlight. Approved by the FDA and NSF for food and drinking water applications.

Use Impolene tubing for air lines, control panels, instrumentation and lubrication systems, processing and construction machinery—many other uses.

Available in 500′ to 1000′ spools in O.D. from ⅛″ to ⅜″. Other sizes available on special order.

Poly-Flo Fittings—designed for use with all plastic tubing, yet usable with soft metal tubing. Withstand pressures beyond burst strength of tubing. Available in a complete range of sizes and styles.

Now Imperial-Eastman meets all your requirements for hydraulic-pneumatic-flow system components: tube fittings, valves, couplings, flexible and rigid hydraulic and pneumatic lines, thermoplastic tubing, tubing tools.

TUBING

IMPERIAL — EASTMAN

ICS PANHANDLE PETE

WESCO! Announces Study Course in Analytical Techniques

The field of analytical techniques is accelerating and expanding; proper understanding of the fundamentals and equipments is essential to modern science and engineering. WESCO! thus announces a 5-day course in the proper use of the Kanarienvogle gas analyzer at all altitudes. Laboratory demonstrations will be included. The course will be taught by top scientists of both WESCO! and the extension division of the University of Southern Wheeling. The course will include:

- Effect of Mechanical Vibration on Kanarienvogle Analyzers
- Transient Response of Kanarienvogles
- Steady-State Response of Kanarienvogles
- LaGrange Energy Functions of Kanarienevogles
- Care and feeding of Kanarienvogles
- Analog Simulation of Kanarienvogles
- Probability Distributions of Kanarienvogles
- Digital Stimulation and Excitation of Kanarienvogles
- Correlation Functions of Kanarienvogles
- Optimization of Kanarienvogles and Use of By-Products

Take this fine opportunity to keep up with your field and to exchange views and cross fertilize other leaders in your field. Tuition: $500 per person.

Look for Panhandle Pete's description of a day in the life of "The Instrument Salesman"—in a future issue.

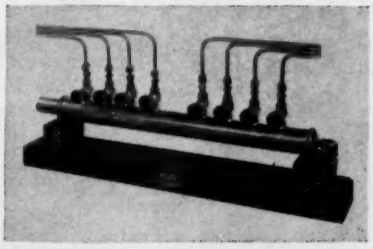
SHELL · VETERANS ADMINISTRATION · Air Products

Judging by the Company We Keep...

Electro-Mech

...**"The Company We Keep" insist on perfection in their Control Systems...excellence in workmanship is a hallmark of Control Systems custom manufactured by Electro-Mech.**

For one example, consider the Electro-Mech cast bronze air-header, which we use in "supply-air" service on pneumatic control system jobs. This leak-proof, sturdy unit makes a more dependable total installation.



A little thing, you say...it is a little thing, but many small improvements in construction details make the difference between an ACCEPTABLE control panel, and one that's UP TO ELECTRO-MECH STANDARDS.

We invite you to join the "Company We Keep" by requesting an Electro-Mech quotation on YOUR next Control Systems requirement.

Electro-Mech Corp., Norwood, N. J.

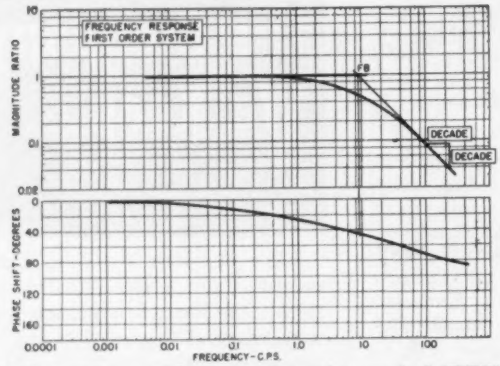
Electro-Mech

CIRCLE 60 ON READER-SERVICE CARD

ICS **BRIEFS**

Frequency Break Point

Frequency Break Point—A figure which gives some indication of the speed of response of a controller or system . . . Asymptotes drawn at the highest and lowest frequencies tested on the magnitude ratio curve will produce an intersection known as the frequency

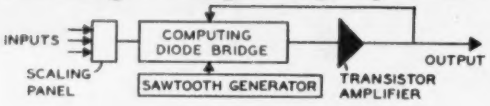


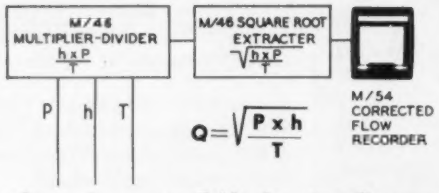
break point . . . (shown at the point marked "FB").

The slope of the asymptote beyond the frequency break point will indicate the order of the system. A magnitude ratio decrease of 10 fold per frequency decade indicates a first order system. (A decade on a logarithmic scale is any multiple of 10 such as 0.3 to 3.0, 8 to 80, etc.) Also, for first order systems, it will be noted as shown . . ., that the break frequency occurs at a phase shift of 45°. First order systems will have a maximum phase shift of 90° . . . (*From* 12-*page Bulletin TM-6, "Fundamentals of Frequency Response," Fisher Governor Co., Marshalltown, Iowa.*)

FOR THIS LITERATURE CIRCLE 186 ON READER-SERVICE CARD

Analog Computing Systems



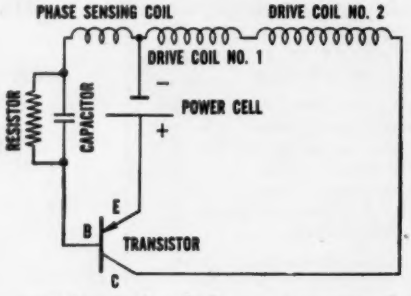


Analog units are available for virtually any task from the simple one of linearizing a flow signal to the relatively complicated pump control problem: . . . Type 66D multiplier-divider [X = AB/C] multiplies, divides, or both multiplies and divides ma d-c signals. Operation is based on a unique diode bridge which is described in Technical Information Sheet 39-164a . . . (*From* 8-*page Bulletin* 1-35, *Foxboro Co., Foxboro, Mass.*)

FOR THIS LITERATURE CIRCLE 187 ON READER-SERVICE CARD

Electronic Timepiece

Bulova Watch Company engineers have now developed a . . . wrist timepiece which eliminates the traditional balance wheel and hairspring, replacing it with



a . . . precision tuning fork . . . A source of energy (the Power Cell) provides power to an electronic circuit, which converts the energy of the cell from direct current to pulses of current. These pulses are used to drive a tuning fork . . . One tine of the fork is linked, by a "ratchet-and-pawl" indexing mechanism, to a conventional gear train, which drives the hands . . . (*From* 40-*page Technical Information and Service Manual, Bulova Watch Co., Inc., Bulova Park, Flushing* 70, *N. Y.*)

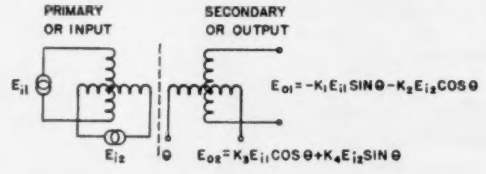
FOR THIS LITERATURE CIRCLE 188 ON READER-SERVICE CARD

Computing Resolver

Simply stated, a computing resolver is a rotatable transformer whose output obeys the equation

$$E_{o1} = K_1 E_{i1} \sin \theta$$

where θ is the rotor angle relative to the stator and K_1 is the complex transformation ratio. When it is necessary to compute this simple trigonometric function in



Schematic of Typical Resolver

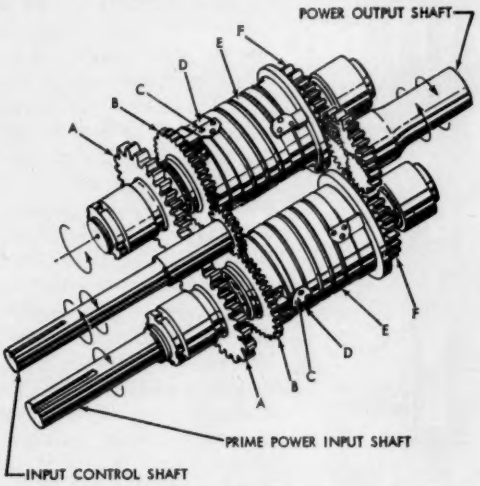
an analogue computer, the computing resolver is employed. For most applications such a computation is too elementary, so another output winding is added permitting the design engineer to simultaneously utilize both a sine and cosine function. . . . Compensated resolvers are still more sophisticated. The objective of compensation is to produce a complex transformation ratio which is virtually independent of temperature and impedance loading. Several techniques are used, but the schematic and equations shown comprise the basic computing resolver . . . (*From* 16-*page Primer for Computing Resolvers, Theta Instrument Corp.,* 520 *Victor St., Saddle Brook, N. J.*)

FOR THIS LITERATURE CIRCLE 189 ON READER-SERVICE CARD

Mechanical Power Amplifier

The Seneca Falls Mechanical Power Amplifier is a simple power servo drive . . . Its principle of operation is an adaptation of the windlass . . . It has excellent dynamic response, permitting the design of high sensitivity control systems . . .

The prime power input shaft drives gears "A" which in turn rotate the two drums "D" in opposite



directions at constant speed. The input control shaft and its pinion drive the free rotating gears "B". As gears "B" rotate, their attached arms "C" rotate and cause the input end of one of the multi-turn bands "E" to contact its drum. (The other band is moved away from its drum.) Friction between the input end of this band and its drum causes the additional turns of the band to rotate and contact the drum—with increasing torque available. The high torque available at the output end of the band rotates gear "F", and in turn, the power output shaft . . . (*From* 2-*page Bulletin EE*1009, *Seneca Falls Machine Co., Electronics Div., Seneca Falls, N. Y.*)

FOR THIS LITERATURE CIRCLE 190 ON READER-SERVICE CARD

Strain Gage Calibration Unit

Accurate strain measurments at any temperature demand some prior knowledge of the performance of the strain measuring device at that temperature. For

strain gages, this requires a knowledge of the gage factor at the temperature in question. It may also require knowledge of the resistance vs temperature curve and the creep behavior of the mounted gage . . .

The gages are attached to a constant strength cantilever beam which is placed in bending by a stepped sliding block at the beam's free end. This subjects the gages to accurately known strains regardless of where on the surface of the beam the gages are mounted . . . (*From* 4-*page Bulletin* 61-101, *Cryogenic Research Co.,* 2965 *Peak Ave., Box* 881, *Boulder, Colo.*)

FOR THIS LITERATURE CIRCLE 191 ON READER-SERVICE CARD

THE SPOT GALVANOMETER

Laboratory Accuracy . . . Shop Ruggedness

The Cambridge Spot Galvanometer provides a complete outfit—galvanometer, lamp and scale—in one self-contained plastic case. It is robust, has a stable zero and does not require accurate levelling. The sharply defined spot can easily be read at a distance. The lamp may be operated on A.C. current or 6-volt battery. Sensitivities are 19, 30 or 170mm. per micro-ampere using coils of 20, 50 and 400 ohms respectively. Scale can be read to 0.2 mm.

OTHER GALVANOMETERS ARE AVAILABLE FOR A VARIETY OF APPLICATIONS IN INDUSTRY AND RESEARCH.
SEND FOR PRINTED LITERATURE.

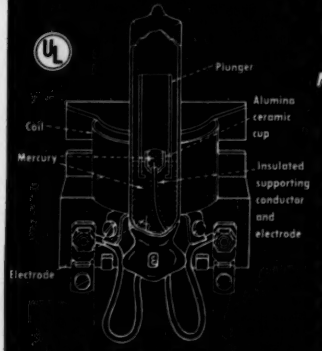
CAMBRIDGE INSTRUMENT CO., INC.

1661 Graybar Bldg., 420 Lex. Ave., N.Y. 17, N.Y.

PIONEER MANUFACTURERS OF PRECISION INSTRUMENTS
CIRCLE 62 ON READER-SERVICE CARD

FREE

ENGINEER'S FACT FILE



Available in Single Pole, Double Pole or Triple Pole Units

MERCURY PLUNGER RELAYS

From 20 to 100 AMPS

FREE: Practical reference manual. Fully illustrated. Covers all types and uses of Mercury Plunger Relays that provide millions of makes and breaks without maintenance. Constant, uniform action. Hermetically sealed, silent and reliable, trouble-free!

Send for your copy. You will find it useful.

EBERT ELECTRONICS CORP.

212-A94 Jamaica Ave., Queen Village 28, N. Y.

CANADA: Philips Electronics Industries Ltd., Toronto 17
EXPORT: Philips Export Co., New York City

CIRCLE 63 ON READER-SERVICE CARD

NEW! King COMPRESSED AIR FILTERS

20 to 200 scfm
¼" to 2" NPT

REMOVE ALL HARMFUL TRACES OF DIRT, WATER AND OIL—

GO MONTHS WITHOUT MAINTENANCE!

HERE'S HOW:

1 WET SCRUBBER CARTRIDGE causes mist and fog particles to form large drops that fall off bottom into sump. Takes out dirt, water and oil down to *less than 2 microns*. Self-cleaning; has *almost unlimited service life.*

2 DRY POLISHER CARTRIDGE removes practically the *last remaining traces* of dirt, water and oil; leaves the air *exceptionally clean*. Scrubber does nearly all the work, so Polisher also has *almost unlimited service life.*

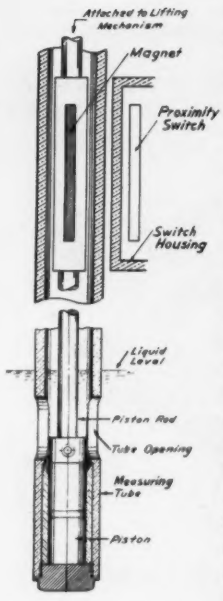
These and other features give a *new low in air-cleaning cost*—with a *new high in protection* to air-actuated equipment and processes.

KING FILTER CATALOG gives *ALL* the facts. May we send you a copy?

KC INSTRUMENTS **KING ENGINEERING CORP.**
3205 S. State St. Ann Arbor, Mich.
LIQUID LEVEL GAGES, MANOMETERS, ACCESSORIES—SINCE 1937

CIRCLE 64 ON READER-SERVICE CARD

Viscometer

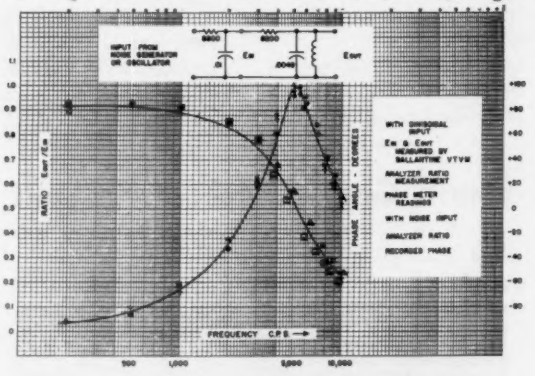


A piston and rod assembly . . . is periodically raised by an air lifting mechanism (not illustrated) drawing a sample of the liquid to be measured in through the tube openings. The liquid then goes down through the clearance between the piston and the inside of the tube into the space which is formed below the piston as it is raised . . . The assembly is then allowed to fall by gravity, expelling the sample out through the same path as it entered. The time of the fall is a measure of viscosity, with the clearance between the piston and the inside of the tube forming the measuring orifice. The measured time of fall starts when the air is shut off and ends when a magnet embedded in the piston assembly (near the top) operates the proximity switch . . . (*From 2-page Bulletin V-1231, Norcross Corp., 247 Newtonville Ave., Newton 58, Mass.*)

FOR THIS LITERATURE CIRCLE 192 ON READER-SERVICE CARD

Cross Spectral Analyzer

Honeywell's Cross Spectral Analyzer System processes automatically and accurately a maximum volume of complex wave data. Vibration, stress, noise, fatigue



Example of transfer function recording with a Honeywell Two-Channel Analyzer

or any other force that detracts from product reliability can be defined and studied with the Analyzer . . . Cross Spectral Analysis is used whenever an interrelation of two or more spectra is to be examined. The cross spectral method establishes the transfer function between two points in a system undergoing test exposure to random processes. If the relationship among three variables is established and two of them are known, the third can be determined . . . (*From 16-page Brochure DB-1075, Minneapolis-Honeywell Regulator Co., Industrial Systems Div., 10721 Hanna St., Beltsville, Md.*)

FOR THIS LITERATURE CIRCLE 193 ON READER-SERVICE CARD

CIRCLE 65 ON READER-SERVICE CARD→

SKINNER provides custom flexibility in standard solenoid valves

Versatile, top quality V5, X5 line offers wide range of options

Skinner's two-way and three-way V5, X5 series of solenoid valves has earned the description—"The Universal Line." With more than 100,000 variations possible, V5, X5 valves are available for every conceivable application. And top quality is emphasized with bubbletight sealing, and stainless steel body, plunger and sleeve assembly. Precision machining, unique welding techniques, specially designed and developed machinery and manufacturing methods are all used by Skinner to produce the best valves made. These valves are small, yet handle operating pressures as high as 3000 psi. They accommodate all media that do not corrode stainless steel. And no other solenoid valves offer so many optional features. Check the following options.

FLOW CONTROL

Precise, accurate control of media flow is possible with all Skinner V5, X5 valves. Both two-way and three-way valves are available with adjustable flow in the main stream, and with manual override. Two-way valves are also available with adjustable bypass. Exhaust flow can be controlled in three-way valves.

ELECTRICAL HOUSINGS

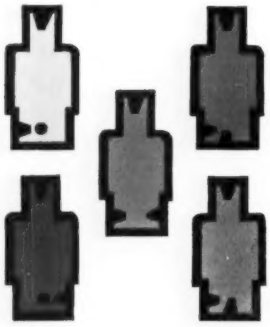
Skinner offers an electrical housing for any application. Some of the most common are:

- standard ½" NPT conduit
- grommet outlet
- single or double automotive terminals
- JIC housings with integral junction box
- AN connector for military applications
- strain relief connector for quick disconnect

All housings are steel, plated for wear and appearance, and can be rotated 360° for easy installation.

PORTING

Restrictions of installation or application, and mounting are minimized because Skinner provides a wide variety of port location options. V5, X5 valves are available with ports at right or left angles, on bottom, top, and sides for virtually all combinations of flow.



MOUNTING

Skinner V5, X5 valves are provided with tapped holes for normal mounting, with mounting brackets for panel or other surface, or with flange for direct mounting without threaded pipe connections.

The Skinner V5, X5 series of two-way and three-way solenoid valves provides top quality design with orifices from 1/32" to 3/16" diameter, normally open, normally closed, dual purpose, directional control and multi-purpose, in standard and explosion-proof construction. Also included in this line is a three-way quick-exhaust type which is designed with an additional port to exhaust cylinders 4 times faster than standard types.

COILS

Skinner V5, X5 valves are available with coils of many types for most DC and AC voltages at 25, 50 and 60 cycle frequencies. Whether your requirements are for continuous or intermittent performance, in tropical, high moisture or high temperature environments, or for dual voltage, Skinner UL approved coils are available with leads of several types and lengths.

• • •

Typical applications—machine tools, cylinder control, instrumentation and automation of all kinds, laundry equipment, aircraft and missiles, etc. For catalogs and complete information contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

When you specify solenoid valves, specify Skinner. Skinner solenoid valves are distributed internationally.

SKINNER ELECTRIC VALVES®

THE CREST OF QUALITY

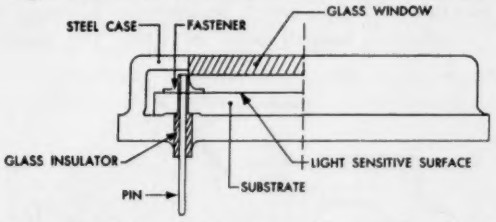
SKINNER ELECTRIC VALVES

SKINNER ELECTRIC VALVE DIVISION,
THE SKINNER CHUCK COMPANY • NEW BRITAIN, CONNECTICUT, U.S.A.

PRINTED IN U.S.A.

Photoconductive Cell

The cadmium sulfide cell, with normal operating current values of 2,000 microamperes, and a response to light similar to that of the human eye, has found



wide use in light sensitive controls. . . . The photoconductive wafer consists of a substrate, ceramic-alumina or Pyrex, on which a water solution of cadmium sulfide, copper salt and chloride has been fired in air at 500°C to 700°C. . . . The electrode material is applied by evaporation of gold, tin, or indium . . . Pin-type contacts are secured to the wafer by Tinnerman pressed-on type fasteners . . . (*From 5-page bulletin, Fisher-Pierce Co.,* 170 *Pearl St., S. Braintree* 85, *Mass.*)

FOR THIS LITERATURE CIRCLE 194 ON READER-SERVICE CARD

Microcircuit AGC Preamplifier

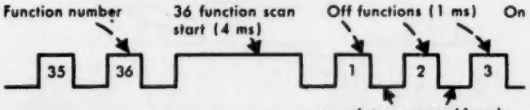
New microcircuit preamplifier consists of a low-noise 6-stage audio amplifier, a dc AGC amplifier, and associated AGC diodes. The output circuit and d-c supply voltage utilize a common 2-wire system. The amplifier is encapsulated in an epoxy resin to form a rugged solid package measuring 0.7″ x 0.65″ x 0.22″ and weighing 3.5 gm. The unit features voltage gain of 80 db minimum below AGC threshold, with equivalent input noise of less than 1 microvolt (input shorted). Harmonic content is less than 10%.—*Varo Mfg. Co., Inc.,* 2201 *Walnut St., Garland, Texas.*

FOR THIS LITERATURE CIRCLE 195 ON READER-SERVICE CARD

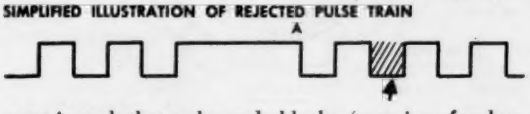
Electronic Monitoring Systems

The Lynch B1020 Electronic Monitoring System provides . . . continuous scanning and transmission of the system . . . The unique Lynch coding arrange-

SIMPLIFIED ILLUSTRATION OF NORMAL PULSE TRAIN



SIMPLIFIED ILLUSTRATION OF REJECTED PULSE TRAIN



ment is such that pulse code blocks (a series of pulses which represent six consecutive functions) are not of constant length, but vary in "bit" steps that are proportional to the number of functions which are in the "on" or "off" condition. This variation permits the logic circuits to evaluate the general correctness of the received code and cast out improper code combinations. . . . (*From 8-page booklet, Lynch Communication Systems Inc.,* 695 *Bryant St., San Francisco* 7, *Calif.*)

FOR THIS LITERATURE CIRCLE 196 ON READER-SERVICE CARD

CUT ENGINEERING COSTS WITH *Dillon* PRECISION

FORCE CONTROL SWITCHES

BI-METAL THERMOMETERS (Fahrenheit or Centigrade)

FORCE GAUGES Compression or Tension

Vital instruments for O.E.M.'s and users ... in laboratory, shop or field!

Faced with a tough engineering problem in temperature or force measurement? If so, let Dillon specialists wrestle with it...chances are we've helped solved *similar* needs for others. A wide range of Fahrenheit and Centigrade thermometers with stems from 1″ to 72″. Force control switches from subminiature to 50,000 lbs. "Push-pull," compression or tension model force gauges. All modestly priced – *dependably* accurate!

VALUABLE FREE ENGINEERING BROCHURES

A full library of scientific data, charts and specifications to save you important time. Complete capacities and prices. Specify brochures desired.

Thermometers ☐ Force Control Switches ☐ Force Gauges ☐

563

TO MEASURE, WEIGH, TEST OR CONTROL – CALL ON DILLON ...PRECISION INSTRUMENTS FOR 3 DECADES!

W. C. *Dillon* & COMPANY, INC.

DEPT. 113, 14584 KESWICK STREET, VAN NUYS 73, CALIFORNIA

Representatives in All Principal Cities

CIRCLE 66 ON READER-SERVICE CARD

EPLAB

PYRHELIOMETER
For the Measurement of
SOLAR RADIATION

Eppley Pyrheliometers are used for solar radiation measurements at ninety-eight weather stations in the continental United States, Canada, Alaska, Greenland, Iceland, Caribbean Sea, and the Pacific Ocean. Sixty-two of these stations are under the direction of the United States Weather Bureau.

The Eppley Pyrheliometer was adopted as standard equipment by the Weather Bureau after considerable experimentation. It was found to be the best instrument so far tested by the Bureau.

Used in conjunction with a suitable recorder, the Eppley Pyrheliometer will provide an accurate and reliable record of total solar and sky radiation on a horizontal surface.

Bulletin No. 2 on Request

THE EPPLEY LABORATORY, INC.

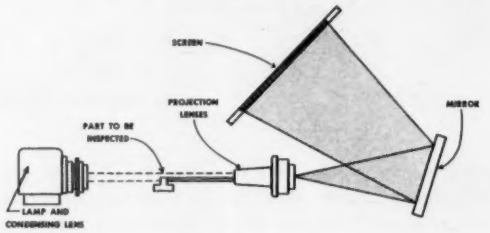
Scientific Instruments

2 Sheffield AVE.
Newport, Rhode Island U. S. A.

CIRCLE 67 ON READER-SERVICE CARD

Optical Comparator

The Optical Comparator is a precision machine which inspects and measures objects speedily and accurately . . . The part to be inspected is placed in a concentrated, parallel beam of light. The resulting

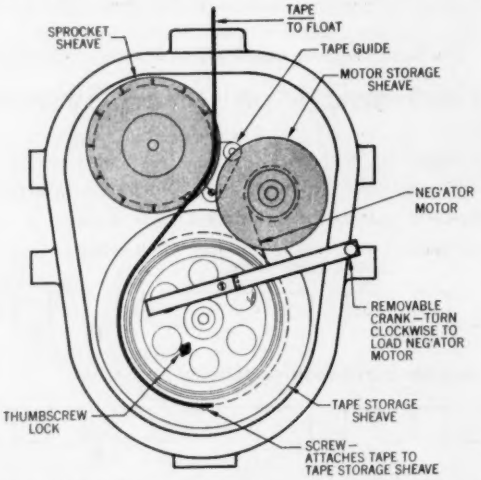


shadow is magnified by a lens system, and projected upon a viewing screen. Here, the enlarged shadow image can be inspected and measured easily and quickly, by comparing it with a master chart or outline on the screen . . . To pass inspection, the shadow outline of the object must correspond exactly to the outline on the chart, or fall within predetermined tolerance outlines on the chart. By moving the part, any dimensions or inaccuracies can be measured precisely, by means of measuring attachments on the machine . . . (*From 62-page catalog including 20 applications, Jones & Lamson Machine Co., Springfield, Vermont.*)

FOR THIS LITERATURE CIRCLE 197 ON READER-SERVICE CARD

Automatic Tank Gauges

The Neg'ator Motor (a long deflection constant force spring element) used in Varec Figure No. 2500 Series Automatic Tank Gauges, eliminates the need for the

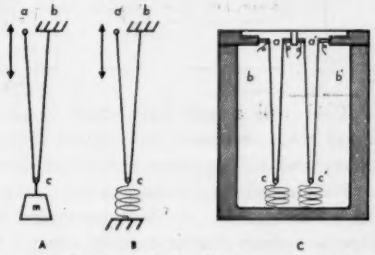


old cumbersome counterweight . . . The patented motor is a strip of flat spring stainless steel which has been given a curvature by continuous heavy forming at a constant radius. This means that in its relaxed or unstretched condition, it remains in the form of a tightly wound spiral . . ., permitting a compact mounting within a Gauge Head. Automatic tape compensation for varying weight of tape due to "payouts" . . . (*From 4-page Bulletin CP-3302, Vapor Recovery Systems Co., 2820 N. Alameda St., Compton, Calif.*)

FOR THIS LITERATURE CIRCLE 198 ON READER-SERVICE CARD

Zero-Length Strain Gage

A new unbonded strain gage is called a "zero-length" strain gage because the wire is not stretched between a moving and a fixed point of longitudinal separation, but instead, the moving and fixed points are longitudinally superimposed. Schematic shows the principle. Point a is the moving point whose position is

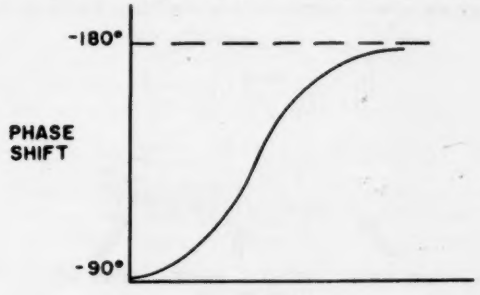


to be measured. Point b is fixed . . . Electrical connections are made at a, b, and c, so that the gage elements ac and bc operate in push-pull . . . C shows how the principle of the zero-length unbonded strain gage is used to construct a complete bridge with all four elements active.—(*From new 28-page catalog, Statham Instruments, Inc.*, 12401 *W. Olympic Blvd., Los Angeles 64, Calif.*)

FOR THIS LITERATURE CIRCLE 199 ON READER-SERVICE CARD

Motors for Servo Systems

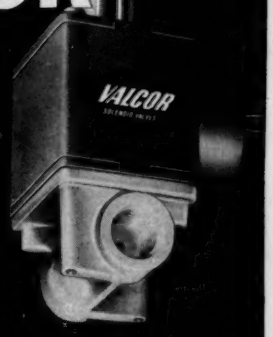
Classes of motors . . .: (1) Standard Low Inertia Servo Motors for precision servos where rapid reversal and high velocity are necessary; (2) Servo Motors with High Inherent Damping (Low Time



Constant) provide greater damping by reducing maximum speed without external means . . .; (3) Viscous Damped Servo Motors provide even greater damping . . . by means of a low inertia drag cup coupling a fixed magnetic field . . . (4) Inertial Damped Servo Motors introduce the equivalent of viscous friction into a loop for stabilization without causing velocity lag. These make possible system cut-off frequencies up to 25 cps. (5) Drag-Cup Servo Motors of very low inertia and friction are designed for low starting voltages and wide dynamic range. (6) Synchronous Motors feature constant speed for timing applications . . . (*From 56-page text, "Technical Information for the Engineer—Servo Motors, Tachometer Generators, Motor Generators, Synchros," Kearfott Div., General Precision Inc., Little Falls, N. J.*)

FOR THIS LITERATURE CIRCLE 200 ON READER-SERVICE CARD

Select from over 3,500 different SOLENOID VALVES from VALCOR



Series SV-54 (3 way-4 way) general purpose solenoid valves for air, oil and water. Rugged construction, yet inexpensive. Multi-million cycle life. Pressure ratings up to 150 psi. Nylon seat outlasts steel. Infinite varieties available! . . . lists as low as $10.75.

Series SV-61 (2 way) Nylon body valve is ideal for general purpose and OEM installations where millions of operating cycles are vital. Nylon seat and port threads outlast steel, yet cost less. Non-corrosive, shock-resistant, proof-pressure.

Series SV-5100 Specifically designed to handle the most corrosive media in industry. Manufactured in Teflon, PVC and Nylon varieties. Diaphragm construction prevents media contact with any metal. Available in direct-acting or piloted models.

VALCOR SOLENOID VALVES

FREE...new 16 page brochure —lists over 500 corrosive media—coded for correct valve selection.

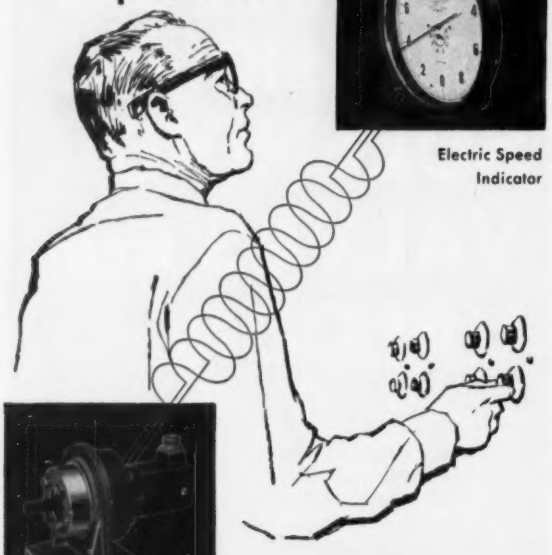
For complete information on these or other models, write or call:

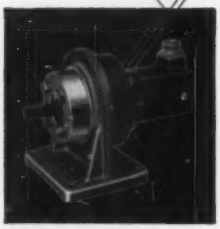
VALCOR ENGINEERING CORP.
5366 Carnegie Ave., Kenilworth, N. J.
CHestnut 5-1665

CIRCLE 68 ON READER-SERVICE CARD

LET'S "phase" IT...

Electric Speed Indicator





3-Phase Tachometer Generator Assembly

ENGINEERS DEPEND ON MERIAM 3-PHASE SPEED INDICATING SYSTEMS

From rugged heavy-duty tachometer generator to aircraft-type dial . . . every detail of MERIAM Balanced 3-Phase Speed Indicating Systems are designed for unfailing duty in hazardous and non-hazardous locations. Featuring continuous repetitive accuracy plus high-visibility indicators MERIAM systems keep going under moisture, temperature and vibration conditions . . . where others fail! Small wonder that more and more production men and engineers depend on . . . insist on . . . these precise systems. High generator output permits remote installation of the indicator as far as 500 feet away from the generator. The large 6-inch dial with 3½ pointer revolutions gives full scale of 66 inches plus over-range protection. System accuracy is 0.3 of 1% of full scale over linear range.

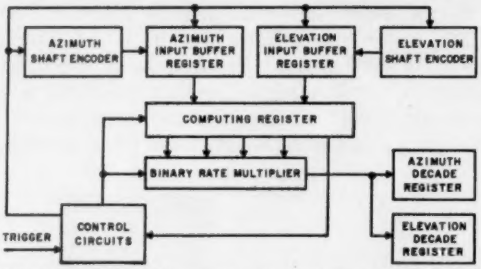
Send for Bulletin 1000 and specifications today...

THE MERIAM INSTRUMENT CO.
I L S ELECTRONIC DIV.
10902 Madison Avenue
Cleveland 2, Ohio

J0034-M1

CIRCLE 69 ON READER-SERVICE CARD

Shaft Encoder Translation

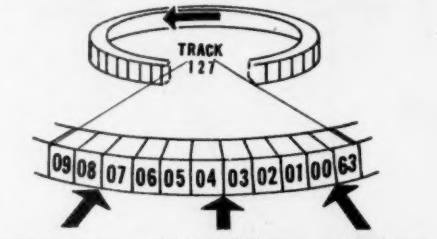


Model X541 will accept the output of two 16-bit cyclic binary shaft encoders, will convert it to conventional binary and will produce individual decimal indication of each encoder output, scaled to the nearest hundredth of a degree . . . Shaft-positioned masking discs allow the photo-electric cells to receive light in a binary (Gray) code pattern, indicative of the shaft position. The corresponding binary voltage pattern from the cells is used for readout. . . . Conversion from Gray code to conventional binary is accomplished in buffer registers by a simple shifting action. . . . (*From 8-page brochure, Harvey-Wells Electronics, Inc., 14 Huron Dr., Natick, Mass.*)

FOR THIS LITERATURE CIRCLE 201 ON READER-SERVICE CARD

High-Speed Storage

There is one track on the drum . . . called an "eight-word high speed line," since eight words of information are duplicated eight times . . . This high speed storage provides one millisecond (average) access-time to any of the eight words in the track. Its primary value is for quicker access to data which is referred to many times by a program. The extremely rapid access affords significant advantages in program-execution time.



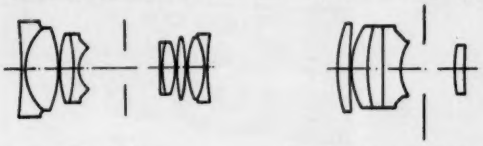
Since eight sector addresses will select the same word, the programmer may select that one which affords minimum access time to the data in this line.

Note: The high speed line may be considered as eight "identical blocks" (utilizing a common drum track) of eight sectors each wherein the same eight words are recorded in all blocks but with non-conflicting, separate addresses. The read-write head is "in phase" with the main-memory and is used for data insertion and retrieval. The individual read-head and write-head are employed for the recirculation process only . . . (*From 26-page RPC-4000 Features Manual, Royal McBee Corp., Westchester Ave., Port Chester, N. Y.*)

FOR THIS LITERATURE CIRCLE 202 ON READER-SERVICE CARD

Cine Lenses

Newest optical designs provide higher speed with unsurpassed definition, and uniform spectral transmission of light for all focal lengths (consistently correct color balance is maintained when several lenses



Cinegon 1:1,8 10 mm Cine-Tele-Xenar 1:2,8 75 mm

may be used in the course of filming). Wider angle of view provided by the new wide angle lens of shorter focal length. . . . Mechanical features include click stops which may be disengaged for smooth, complete fades . . . Automatic depth of field indicator window gives constant indication of exact depth being covered, self-adjusts according to f stop and distance. . . . (*From* 24-*page Catalog* 2, "*Schneider Lenses*," *Burleigh Brooks Inc.*, 420 *Grand Ave., Englewood, N. J.*)

FOR THIS LITERATURE CIRCLE 203 ON READER-SERVICE CARD

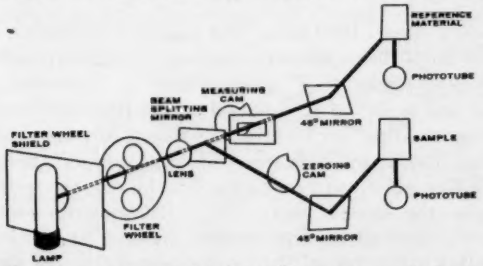
Pressure-Sensitive Paints

One drop of Celab Pressure-Sensitive Paint makes a pressure-transducer having almost no weight or volume. It is applicable to a surface of any shape, and . . . can be applied to any metal or conducting surface . . . It requires application between two conducting surfaces. When vacuum coated it forms a barometric pickup. If placed over a magnet or solenoid with a soft iron contactor on top, it can be a solid state relay without moving armature or contacts, a magnetometer, amplifier, or indicate wind or water pressure . . . High Sensitivity Type 5—over 100K ohms resistance change per ounce of force. Range 0-2 lb on. .5" dia. area . . . (*From* 4-*page bulletin, Clark Electronic Laboratories, Box* 165, *Palm Springs, Calif.*)

FOR THIS LITERATURE CIRCLE 204 ON READER-SERVICE CARD

Differential Colorimeter

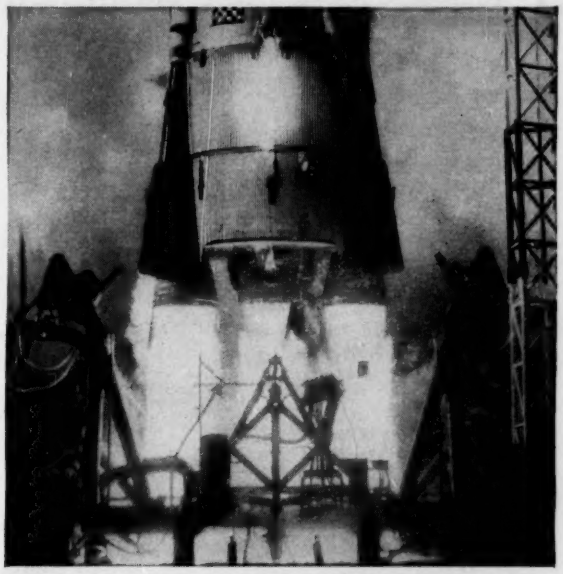
The COLORMASTER is a tri-stimulus filter colorimeter employing the latest and most advanced optical null balance system. A light beam is transmitted through or reflected from a sample to a phototube.

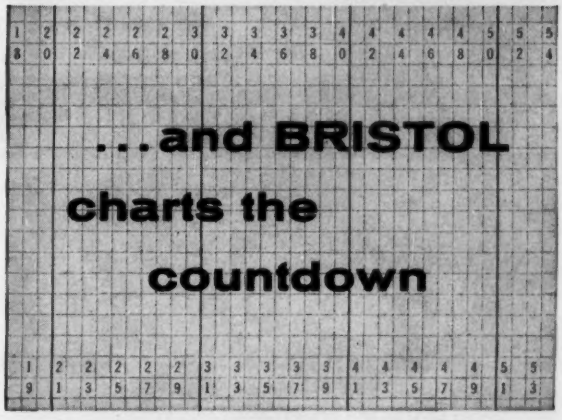


Reflectance or transmitted readings are made by adjusting the intensity of a reference light beam . . . Filters have been designed so that spectral response of the source-filter phototube combination accurately simulates the C.I.E. tri-stimulus specification of illuminant C (standard artificial daylight) . . . (*From* 4-*page Bulletin CM*-1200, *Manufacturers Engineering & Equipment Corp.*, 16 *Maple St., Summit, N. J.*

FOR THIS LITERATURE CIRCLE 205 ON READER-SERVICE CARD

ATLAS AWAY!





Bristol charts (sample above) in specially built "time and event recorders" at Vandenberg Air Force Base tell engineers vital facts about the critical moments in the countdown and first few minutes of flight of each Atlas missile.

Printed for Convair (Astronautics) Division of General Dynamics Corporation, prime contractor for the Atlas missile, these charts are just one example of the hundreds of "specials" turned out every year at Bristol chart printing facilities—one of the largest, most complete plants of its kind in the country.

Strip charts up to 32" across, circular charts to 12" diameter can be handled. Standard chart papers of highest quality are available. Or, Bristol can print on a wide variety of special papers, such as papers for metallic marking, foil-type laminates, card stock, heat- and pressure-sensitive, carbon-coated, or photo-sensitive oscillographic papers.

Get in touch with Bristol if you're designing a special recording instrument. An entire special chart engineering service is at your disposal. Or, for more information about this service, write for Bulletin Y1906. The Bristol Company, 154 Bristol Road, Waterbury 20, Conn. 9.29

BRISTOL ... for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

CIRCLE 70 ON READER-SERVICE CARD

INSULATION TESTING

Engineering • Production • Maintenance

✓ **Materials**
✓ **Components**
✓ **Equipment**

High Voltage Breakdown
HYPOT Test Sets with outputs from 5 kv to 150 kv and up. Test wire, cables, transformers, motors and components to ASTM and Federal specifications. Write for manual.

Mobile HYPOT for testing heavy duty electrical equipment.

Insulation Resistance
VIBROTEST Megohmmeters have direct reading ranges to FIVE MILLION Megohms. Self-contained electronic power supply eliminates cranking and leveling. Write for manual.

Model 4501 HYPOT Materials Tester. Meets D-149 etc., ASTM specifications.

Insulation Materials Tester
Interchangeable test fixtures for tape, plastic sheet, film, tubing, porcelain, cloth and varnishes. Models provide 35 kv and up for test.

Insulating Oils Tester
Dielectric strength testing of insulating liquids to ASTM specifications. Rapid, simplified operation. Automatic rate of rise control optional.

Model 4505 HYPOT Oil Tester provides 0-35 kv at 2 kva.

Arc Resistance Tester
Tests ability of insulating materials to resist arcing in accord with ASTM and Federal specifications. Complete with electrode assembly and specimen holder.

Write for Manual J-67

10-35.21

ASSOCIATED RESEARCH, Incorporated
"Electrical Testing Instruments Since 1936"

3766 W. Belmont Ave. • Chicago 18, Illinois
CIRCLE 74 ON READER-SERVICE CARD

2 important ad-readership survey issues . . .

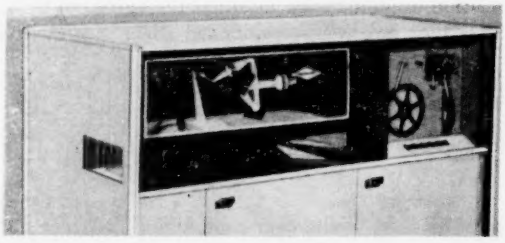
MARCH AUGUST

John T. Fosdick Associates will conduct, among **Instruments & Control Systems** readers, a Study of Advertising and Editorial Readership. The resultant performance ratings are related to the readers job function, for heightened significance.

Be sure to advertise in one of these Study Issues. Contact any of ICS' reps, listed on page 372—or write, wire, or call **Instruments & Control Systems**, 845 Ridge Ave., Pittsburgh 12, Pa. FAirfax 1-0161.

Electronic Reading Machine

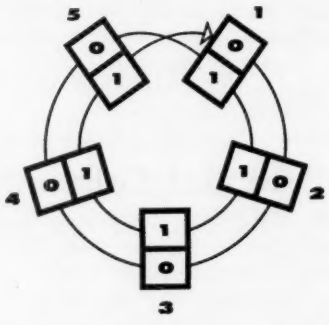
The Farrington Optical Scanner Model 1P5P . . . world's first commercial page reader . . . reads upper



and lower case alphabetic characters, common punctuation marks, and numeric characters, 0-9. Model 1P5P has ability either to read full pages of typewritten information, single or double-spaced, or to scan entire pages in search of particular information, further translating it into a punched paper tape code. Whether the 5-level or the 6-level code is used, the page reader scans and punches 240 characters per second, automatically feeding from page to page . . . The 1P5P offers automated systems in such areas as communications transmission, type-setting, data reduction, scientific literature abstraction, catalog-indexing and language translation . . . (*From 4-page bulletin, Farrington Mfg. Co., Needham Hts. 94, Mass.*)

FOR THIS LITERATURE CIRCLE 206 ON READER-SERVICE CARD

100-Mc Gated Counter



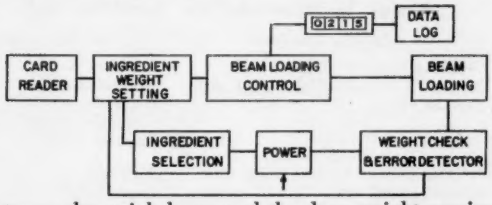
New Model 1060 is the first practical application of 100 Mc/s direct decimal counting . . . made possible by new "twisted ring" counting logic . . . Operation of the new logic can be followed on the simplified block diagram. The five binaries are shown in reset condition. The arrow indicates that (with proper gating) the first pulse will turn on the first binary, the second pulse the second binary, etc., following the outer circle, until all the five binaries are "on."

Due to the "twist" in the interconnection, the sixth pulse turns off the first binary, etc., following the inner circle. The binaries are reset to their original condition with the tenth input pulse . . . When used as a time interval meter, . . . the Minimum Time Interval has been shortened to 10 nanoseconds . . . (*From 4-page Bulletin D-1050, Eldorado Electronics, 2821 Tenth St., Berkeley 10, Calif.*)

FOR THIS LITERATURE CIRCLE 207 ON READER-SERVICE CARD

Batch Control System

The DYNABATCH achieves an accuracy equal to that of the null balance servo-driven poise beam. . . A parallelogram linkage with flexure pivots is used



between the weigh beam and the drop weight receiver platform. Exact positioning of the drop weights is not critical because accuracy is determined primarily by the individual accuracy of the drop weights. Drop weights can be calibrated to any accuracy required . . .

The combination of high speed, accuracy, and ease of changing set weight makes the Dynametrics Dynabatch especially advantageous in batching applications . . . (*From* 20-*page Automatic Weighing Catalog* 200, *Dynametrics Corp., Northwest Industrial Park, Burlington, Mass.*)

FOR THIS LITERATURE CIRCLE 208 ON READER-SERVICE CARD

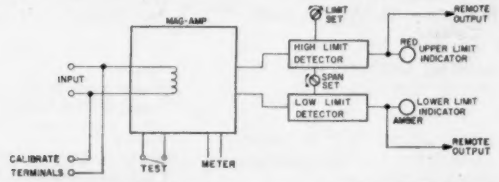
Torque Wrenches

A rule of thumb to use in considering the size of a torque wrench is that the average individual can pull with a force of about 100 pounds . . . The maximum range of a torque wrench should be 600 foot-pounds. Such a torque tool when used within its practical working range would have to have at least a 60 inch lever length . . . Torque applications beyond 600 foot-pounds should be made by using a a torque multiplying device in conjunction with the torque wrench . . . (*From* 31-*page* 3*rd edition Torque Manual covering nomenclature, torque law, uses, adapters, extensions, modifications, and* 14 *illustrated applications, P. A. Sturtevant Co., Addison, Ill.*)

FOR THIS LITERATURE CIRCLE 209 ON READER-SERVICE CARD

Monitor Alarm

The Magne-Alarm is an all-electronic, solid state device using a bistable magamp as its only active element . . . The input signal from thermocouple, strain gage, resistance thermometer or thermistor bridge is



fed into an isolated winding on a magamp. The magamp is factory adjusted so that an input in its operating range produces a differential output into the limit detecting circuits. If this output exceeds the levels set by the high or low limit set controls, the magamp is triggered into a "high" or "low" operating condition and drives the proper alarm light at full brilliance. . . . (*From* 4-*page bulletin, San Diego Scientific Corp.,* 3434 *Midway Dr., San Diego* 10, *Calif.*)

FOR THIS LITERATURE CIRCLE 210 ON READER-SERVICE CARD

SIMULATE PHYSICAL SYSTEMS IN REAL TIME OR REPETITIVELY WITH . . .

Applied Dynamics Analog Computers SERIES **AD-1**

Modular Design For Plug-In Expandability And Maximum Reliability

- Passive-circuit diode multipliers and function generators
- Computing resistors matched to .01%
- Repetitive operation with electronic reset and simultaneous real-time operation
- Continuous overload monitoring and integral balance check system

AD-1 Series analog computers are available with from 4 to 64 amplifiers for solution of various types of linear and non-linear equations.

The AD-1-64PB features a removable preprogrammed patchboard with up to 64 stabilized amplifiers, 80 coefficient potentiometers, 16 multipliers, 8 function generators, and 20 diode networks.

The AD-1-32 and AD-1-16 feature a fixed patchboard system with up to 32 and 16 amplifier capacity and non-linear equipment for maximum economy.

Modular design permits flexible arrangements to suit various operating requirements.

Applied Dynamics, Inc.

A Subsidiary of Bowmar Instrument Corp.

ANN ARBOR, MICHIGAN

Specialists in Industrial and Process Instrumentation and Controls

CIRCLE 72 ON READER-SERVICE CARD

INCREASE RECORDER VERSATILITY

MULTI-SPEED **CHART DRIVE** FOR STRIP CHART RECORDERS

BUILT BY — HONEYWELL — LEEDS & NORTHRUP — BRISTOL — WHEELCO — GENERAL ELECTRIC (EASILY FIELD MOUNTED)

Matches Chart Speed to Test Requirements • Quick dial selection of eight speeds • Improves resolution and readability of plotted curves • Provides greater total chart speed range • Saves chart paper • Saves valuable time.

CHART DRIVES • SPEED REDUCTORS • INSTRUMENT DRIVE SYSTEMS

INSCO COMPANY

DIVISION OF BARRY WRIGHT CORP.
GROTON, MASSACHUSETTS

CIRCLE 73 ON READER-SERVICE CARD

Complete Coverage for only $4.00

CONTROL VALVES

by C. S. Beard

236 pages plus viii, numerous tables & illustrations

Covers: Flow characteristics, mechanical features valve capacity, sizing, body types, positioners, actuators, etc.

$2.00

REGULATORS & RELIEF VALVES

by C. S. Beard and F. D. Marton

204 pages plus ix, 1959, illustrated

. . . this second of the Control Valve series covers mechanically-loaded and pneumatically-loaded pressure regulators; regulators for back pressure, vacuum, flow & pump discharge; temperature & gas regulators, safety & relief valves . . .

$2.00

INSTRUMENTS PUBLISHING CO., INC.
845 Ridge Ave., Pittsburgh 12, Pa.

IGS EVENTS

Major Instrumentation Events—1961

Meeting & Sponsor	Date and Place
INTERNATIONAL SOLID STATE CIRCUITS CONFERENCE—IRE, AIEE, Univ. of Penna.	February 15-17 Philadelphia, Pa. University of Pennsylvania and Sheraton Hotel
PHOTO INSTRUMENTATION ROUNDTABLE AND CLINIC—SPIE	February 16 New York, N. Y. Statler-Hilton Hotel
PITTSBURGH CONFERENCE ON ANALYTICAL CHEMISTRY AND APPLIED SPECTROSCOPY—ACS, SSP	Feb. 27-Mar. 3 Pittsburgh, Pa. Penn-Sheraton Hotel
OSA SPRING MEETING—OSA	Mar. 2-4 Pittsburgh, Pa. Pick-Roosevelt Hotel
INSTRUMENTATION FOR THE IRON AND STEEL INDUSTRY—ISA	Mar. 8-10 Pittsburgh, Pa. Pick-Roosevelt Hotel
ASP ANNUAL CONVENTION—ASP	Mar. 19-25 Washington, D. C. Shoreham Hotel
IRE INTERNAT'L CONVENTION—IRE	Mar. 20-23 New York, N. Y. Coliseum and Waldorf-Astoria Hotel
AMERICAN POWER CONFERENCE—Armour Res. Found.	March 21-23 Chicago, Ill. Sherman Hotel
SYMPOSIUM ON TEMPERATURE, ITS MEASUREMENT AND CONTROL IN SCIENCE AND INDUSTRY—AIP, NBS, ISA	Mar. 27-31 Columbus, Ohio Veteran's Memorial Hall and Deshler-Hilton Hotel
CONFERENCE ON ELECTRO-OPTICAL AND RADIATION DEVICES—IRE, AIEE	April San Jose, Calif.
JOINT AUTOMATIC TECHNIQUES CONFERENCE—IRE, AIEE, ASME	April Cincinnati, Ohio
PROGRESS IN ELECTRICAL-ELECTRONIC EQUIPMENT EXHIBIT—	Apr. 4-6 St. Louis, Mo. Kiel Auditorium
ANNUAL SYMPOSIUM, ELECTRONIC PROCESS INSTRUMENTATION—ISA	April 4 Newark, N. J. Hotel Essex House
INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETICS AND FLUID DYNAMICS OF GASEOUS PLASMA—IRE, IAS, PIB, Dept. of Defense	Apr. 4-6 New York, N. Y. Eng. Soc. Bldg. Auditorium
ANNUAL MEETING AND EXPOSITION—IES	Apr. 5-7 Washington, D. C. Sheraton-Park Hotel
APPLICATION OF CONTINUOUS ANALYZERS TO PROCESS CONTROL—AIChE	April 7 Marietta, Ohio Marietta College
FEDERATION OF AMERICAN SOCIETIES FOR EXPERIMENTAL BIOLOGY MEETING AND EXHIBIT—FASEB	April 10-14 Atlantic City, N. J. Auditorium
OHIO VALLEY INSTRUMENT EXHIBITION AND SYMPOSIUM—ISA, SAP	April 11-12 Cincinnati, Ohio Cincinnati Gardens
SYMPOSIUM ON BIOMEDICAL ENGINEERING—AIEE, IRE, San Diego Naval Hosp.	April 13, 14 San Diego, Calif.

NATIONAL SYMPOSIUM ON INSTRUMENTAL METHODS OF ANALYSIS—ISA	Apr. 17-19 Houston, Texas Shamrock-Hilton Hotel
SOUTHWESTERN IRE CONFERENCE AND SHOW (SWIRECO)—IRE	April 19-21 Dallas, Texas Memorial Aud. and Baker Hotel
SOUTHEASTERN REGIONAL CONFERENCE AND EXHIBIT—ISA	Apr. 19-21 Charlotte, N. C. Park Center and Public Library
REGIONAL TECHNICAL CONFERENCE AND SHOW—IRE	Apr. 26-28 Phoenix, Ariz. Westward Ho Hotel
NATIONAL AERO-SPACE INSTRUMENTATION SYMPOSIUM—ISA	Apr. 30-May 4 Dallas, Tex. Adolphus Hotel
ELECTRONIC COMPONENTS CONFERENCE—IRE, AIEE, EIA, WEMA	May 2-4 San Francisco, Calif. Jack Tar Hotel
ENGINEERING APPLICATIONS OF A MEDIUM-SIZED DIGITAL COMPUTER—Univ. of Vermont, AIEE	May 4 Burlington, Vt. University of Vermont
NATIONAL POWER INSTRUMENTATION SYMPOSIUM—ISA	May 8-10 Chicago, Ill. LaSalle Hotel
NATIONAL AEROSPACE ELECTRONICS CONFERENCE (NAECON)—IRE	May 8-10 Dayton, Ohio Miami and Dayton Biltmore Hotels
WESTERN JOINT COMPUTER CONFERENCE (WJCC)—IRE, AIEE, ACM	May 9-11 Los Angeles, Calif. Ambassador Hotel
INTERNATIONAL EXHIBITION AND CONGRESS ON MEASUREMENT, CONTROL, REGULATION, AND AUTOMATION (MESUCORA)—MESUCORA	May 9-17 Paris, France National Center of Industry and Techniques
ANNUAL MEETING—SESA	May 10-12 Philadelphia, Pa. Benjamin Franklin Hotel
PULP AND PAPER INSTRUMENTATION SYMPOSIUM—ISA, TAPPI	May 10-12 Green Bay, Wisc. Northland Hotel
NATIONAL TELEMETERING CONFERENCE—IRE, AIEE, ARS, ISA, IAS	May 22-24 Chicago, Ill. Sheraton Towers Hotel
SYMPOSIUM ON LARGE CAPACITY MEMORY TECHNIQUES FOR COMPUTING SYSTEMS—Office of Naval Res.	May 23-25 Washington, D. C. Dept. of the Interior Auditorium
MASS SPECTROMETRY ANNUAL MEETING—ASTM	June 4-9 Chicago, Ill. Sherman Hotel
SUMMER INSTRUMENT-AUTOMATION CONFERENCE—ISA	June 6-8 Toronto, Ont., Can. Royal York Hotel and Queen Elizabeth Hall
EXHIBITION CONGRESS OF CHEMICAL ENGINEERING (ACHEMA)—DECHEMA	June 9-17 Frankfurt/Main West Germany
AIR POLLUTION INSTRUMENTATION SYMPOSIUM—APCA	June 11-15 New York, N. Y. Hotel Commodore
INTERNATIONAL SYMPOSIUM ON GAS CHROMATOGRAPHY—ISA, Michigan State Univ.	June 13-16 East Lansing, Mich. Kellogg Center
ANNUAL MEETING—ASTM	June 25-30 Atlantic City, N. J. Chalfonte-Haddon Hall Hotel
NATIONAL CONVENTION ON MILITARY ELECTRONICS—IRE	June 28-30 Washington, D. C. Shoreham Hotel

Approximately 1/3 Actual Size

INSCO

STEP-FUNCTION SPEED REDUCTOR

AN INSTRUMENT TRANSMISSION FOR PRECISE MULTIPLE SELECTION OF SHAFT SPEEDS

Versatility of ten ratios . . . to 1000:1! Desired shaft speed can be quickly selected at the turn of a dial, without stopping the input shaft. Geared design provides exact repeatability and non-slip drive . . . ideal for new instrument design, breadboards, general laboratory applications.

OIL BATH LUBRICATION . . . SPEEDS UP TO 3000 R.P.M. . . . TORQUE TO 50 OZ.-IN. . . . VARIETY OF MOUNTING ARRANGEMENTS.

CHART DRIVES • SPEED REDUCTORS • INSTRUMENT DRIVE SYSTEMS

INSCO COMPANY

DIVISION OF BARRY WRIGHT CORP.

GROTON, MASSACHUSETTS

CIRCLE 75 ON READER-SERVICE CARD

NO CONTAMINATION OF PRESSURE INSTRUMENTS WATER OPERATED

TYPE WG DEAD WEIGHT PRESSURE GAGE RANGES TO 13,000 PSI

Please request data sheet 593

MANSFIELD & GREEN INC.

1051 POWER AVE. • CLEVELAND 14, OHIO

CIRCLE 76 ON READER-SERVICE CARD

Sensitive
DIFFERENTIAL PRESSURE and VACUUM CONTROLS

J6K
J27KB

By using **UNITED ELECTRIC's** Type J6K or Type J27KB control, it is possible to control accurately the difference in pressure between two pressure or vacuum sources. The J6K contains a single switch; the J27KB is a dual switch control.

System Differential	Up to 90 psi.
Switch Differential	J6K — can be set between limits of ½" Hg and 3 psi. J27KB — can be set between limits of 1" Hg and 5 psi.
Switch Ratings	15 amps. at 115 or 230 volts A.C. Also 20 amps. or D.C. switches on specification.
Switch Types	N.O., N.C., or Double Throw — no neutral position.
Adjustments	J6K — internally located, uncalibrated adjustment wheel. J27KB — each switch has independent, uncalibrated adjustment screw.
Electrical Connections	Made to screw terminals on switches through clearance hole in enclosure.
Pressure Connections	Two ¼" female NPT pressure connections.
Size	J6K — 7 5/32" x 4 27/32" x 2 5/16". J27KB — 7 1/16" x 6 1/8" x 2 7/8".
Approximate Weight	J6K — 2¼ lbs. J27KB — 2 lbs.

UNITED ELECTRIC *manufactures a complete line of temperature, pressure and vacuum controls. Standard units can be modified or custom-built units made to your specifications. Additional information on pressure and vacuum controls is available upon request.*

United Electric Controls
COMPANY
85 SCHOOL STREET, WATERTOWN, MASS

CIRCLE 77 ON READER-SERVICE CARD

INTERNATIONAL MEASUREMENT CONFERENCE (IMEKO)—Hungarian Scientific Society for Measurement and Automation	June 26 to July 1 Budapest, Hungary
JOINT AUTOMATIC CONTROL CONFERENCE—IRE, AIChE, AIEE, ASME, ISA	June 28-30 Boulder, Colo. University of Colo.
INTERNATIONAL CONFERENCE ON MEDICAL ELECTRONICS AND CONFERENCE ON ELECTRONIC TECHNIQUES IN MEDICINE AND BIOLOGY—IRE, AIEE, ISA	July 16-22 New York, N. Y. Waldorf Astoria Hotel
CRYOGENIC ENGINEERING CONFERENCE—Univ. of Mich.	Aug. 15-17 Ann Arbor, Mich. University of Mich.
TESTING CONFERENCE—TAPPI	Aug. 15-18 Montreal, Que., Can. Queen Elizabeth Hotel
WESTERN ELECTRONICS SHOW AND CONVENTION (WESCON)—IRE, WEMA	Aug. 22-25 San Francisco, Calif. Cow Palace
JOINT NUCLEAR INSTRUMENTATION SYMPOSIUM—IRE, AIEE, ASA	Sept. 6-8 Raleigh, N. C. North Carolina State College
INTERNATIONAL SYMPOSIUM ON TRANSMISSION AND PROCESSING OF INFORMATION—IRE	Sept. 6-8 Cambridge, Mass. Massachusetts Institute of Technology
NATIONAL SYMPOSIUM ON SPACE ELECTRONICS AND TELEMETRY—IRE	Sept. 6-8 Albuquerque, N. M.
FALL INSTRUMENT-AUTOMATION CONFERENCE AND EXHIBIT—ISA	Sept. 11-15 Los Angeles, Calif. Memorial Sports Arena Biltmore Hotel
NONLINEAR MAGNETICS AND MAGNETIC AMPLIFIERS CONFERENCE—IRE	October (location undecided)
PROCESS INDUSTRIES CONFERENCE—ASME	Oct. 4-6 Houston, Tex. Shamrock-Hilton Hotel
SEMI-ANNUAL CONVENTION—ASP	Oct. 4-6 New York, N. Y. Baltimore Hotel
NATIONAL ELECTRONICS CONFERENCE—IRE, AIEE, et al.	Oct. 9-11 Chicago, Ill. International Amphitheatre
COMPUTER APPLICATIONS SYMPOSIUM—Armour Res. Found.	Oct. 25-26 Chicago, Ill. Morrison Hotel
ELEC. TEC. IN MEDICINE AND BIOLOGY CONFERENCE—IRE, AIEE, ISA	Oct. 26-27 Omaha, Nebraska Univ. of Nebraska
ANNUAL SESA MEETING—SESA	Nov. 1-3 New York, N. Y. Hotel New Yorker
ANNUAL INSTRUMENTATION CONFERENCE—La. Polyt. Inst.	Nov. 2-3 Ruston, La. Louisiana Polytechnic Institute
MAGNETISM AND MAGNETIC MATERIALS CONFERENCE AND EXHIBIT—AIEE	Nov. 12-16 Phoenix, Ariz. Westward Ho Hotel
NORTHEAST RES. AND ENG. MEETING (NEREM)—IRE	Nov. 14-16 Boston, Mass.
ELECTRON DEVICES MEETING—IRE	Nov. 20-21 Washington, D. C. Shoreham Hotel
EASTERN JOINT COMPUTER CONFERENCE (EJCC)—IRE, AIEE, ACM	Dec. 3-7 Washington, D. C. Sheraton-Park Hotel

ACM—Association for Computing Machinery, c/o Mr. R. E. Utman, Remington Rand Univac, Box 200, Princeton, N. J.

ACS—American Chemical Society, 1155 Sixteenth St., Washington 6, D. C.

AIChE—American Institute of Chemical Engineers, 25 W. 45th St., New York 36, N. Y.

AIEE—American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N. Y.

AIP—American Institute of Physics, 335 E. 45th St., New York 22, N. Y.

APCA—Air Pollution Control Association, 4400 Fifth Ave., Pittsburgh 13, Pa.

ARS—American Rocket Society, 500 Fifth Ave., New York 36, N. Y.

ASME—American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.

ASP—American Society of Photogrammetry, 1515 Massachusetts Ave., N.W., Washington, D. C.

ASTM—American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

DECHEMA—Deutsche Gesellschaft fur Chemisches Apparatewesen (German Society for Chemical Equipment), Rheingau Allee, Frankfurt/Main, West Germany.

EIA—Electronic Industries Association, 11 W. 42nd St., New York 36, N. Y.

FASEB—Federation of American Societies for Experimental Biology, c/o Mr. M. O. Lee, 9650 Wisconsin Ave., Washington 14, D. C.

FCI—Fluid Controls Institute, 320 Broadway, New York 7, N. Y.

IAS—Institute of the Aerospace Sciences, 2 E. 64th St., New York 21, N. Y.

IES—Institute of Environmental Sciences, P. O. Box 191, Mt. Prospect, Ill.

IMEKO—Hungarian Scientific Society for Measurement and Automation, P. O. Box 3, Budapest, Hungary.

IRE—Institute of Radio Engineers, One E. 79th St., New York 21, N. Y.

ISA—Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

MESUCORA—Association for Measurement, Control, Regulation and Automation, 40 Rue du Colisée, Paris (8°), France.

NBS—National Bureau of Standards, Washington 25, D. C.

NACE—National Association of Corrosion Engineers, 1061 M & M Building, Houston, Texas.

OSA—Optical Society of America, 1155—16th St., N. W., Washington 6, D. C.

PIB—Polytechnic Institute of Brooklyn, 55 Johnson St., Brooklyn 1, N. Y.

SAMA—Scientific Apparatus Makers Association, 20 N. Wacker Drive, Chicago, Ill.

SAP—Society for Applied Spectroscopy Boston College, Chestnut Hill 67, Mass.

SESA—Society for Experimental Stress Analysis, 21 Bridge Square, Westport, Mass.

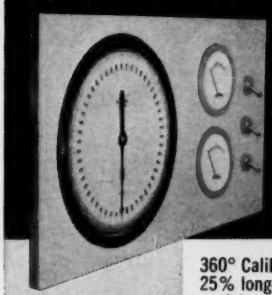
SPIE—Society of Photographic Instrumentation Engineers, P. O. Box 288, Redondo Beach, Calif.

SSP—Spectroscopy Society of Pittsburgh, c/o J. E. Paterson, Westinghouse Research Laboratories, Beulah Rd., Pittsburgh 35, Pa.

TAPPI—Technical Association of the Pulp and Paper Industry, 360 Lexington Ave., New York, N. Y.

WEMA—Western Electronic Manufacturers Association, 701 Welch Road, Palo Alto, Calif.

NEW *Martin-Decker* **Precision Test Gauge** *makes pressure readings* **25% More Accurate**



8½" Dia. Dial—25.13" Scale Length
12" Dia. Dial—36.91" Scale Length

- **Big scale readings in small scale space!**
- **Greater Accuracy!**
- **Requires less panel space!**

360° Calibration makes Martin-Decker Scale 25% longer—gives 25% greater readability than models with 270° scale.

Ni-Span C Bourdon tube is temperature-stable, corrosion-resistant—superior to other alloys.

Tube tip bleed is standard equipment.

Movement calibrated to dial, with an accuracy of ± 0.15% or better.

Uniform linear increments. Protected front zero adjust.

Capacities from 60 PSI to 15,000 PSI.

Find out why more and more O.E.M. designers specify Martin-Decker Precision Test Gauges for measuring gas and fluid pressures.

MARTIN DECKER

Precision Pressure Instruments Testing—Weighing—Load and Force Measurement

Write for Technical Brochure T53

MARTIN DECKER PRECISION TEST GAUGES

MARTIN-DECKER CORPORATION • 3431 Cherry Ave., Long Beach 7, Calif.

CIRCLE 78 ON READER-SERVICE CARD

Rheology/**Viscosity**

Does the quality or cost of your product depend on its flow characteristics?

► A complete line of Epprecht Viscometers provide viscosity measurements in the laboratory or during processing with automatic control of viscosity.

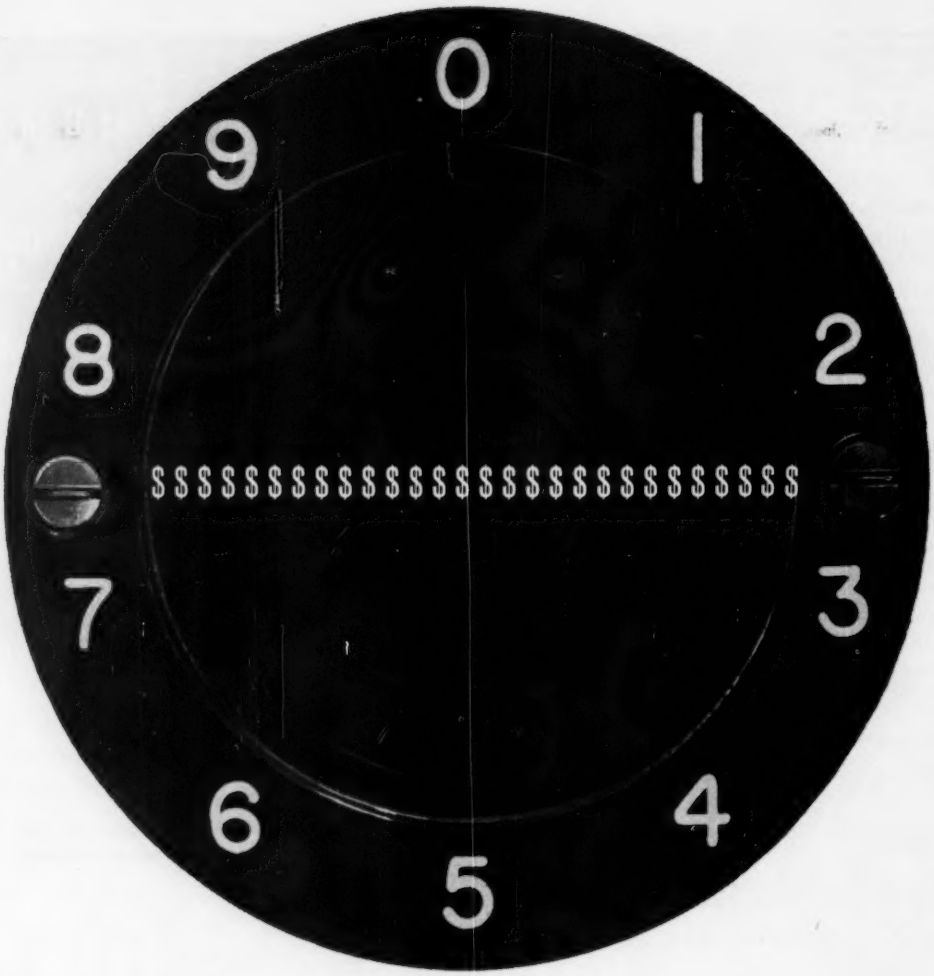
► Measurements can be made at pressures up to 700 psi or in a vacuum at temperatures to 300° C.

For detailed technical information on Epprecht Viscometers write to Dept. DV-29.

J. W. FECKER DIVISION
AMERICAN OPTICAL COMPANY

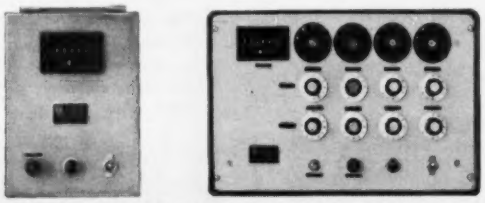
6592 HAMILTON AVENUE • PITTSBURGH 6, PENNSYLVANIA

CIRCLE 79 ON READER-SERVICE CARD



What price Automation? Veeder-Root's electronic answer will surprise you! Now you can buy automatic electronic counting and controlling functions on a "tailored to fit" basis. Just what you need to step up efficiency and cut costs. No more!! No less!! Start with what you want to count... next determine the fastest counting speed you need... then consider how you could automate your equipment by triggering one or more of its operations electrically.

With these basic facts, your Veeder-Root sales engineer can tell you which electronic counters will meet your automation requirements most economically. These compact units can count up to 300,000 times per minute. They can sense objects the size of a pinhead. Control types are easily preset to start, stop and regulate your equipment... and accurately coordinate its production. Find out how little it costs to build automation into your production setup. Write to Electronic Controls Division, Veeder-Root Inc., Danvers, Mass. **count on...Veeder-Root**



The Veeder-Root electronic counter line ranges from the 1697 Count-Pak for counting to 2500 cpm at a unit cost of approximately $100 . . . to the highly versatile 1804 series for counting up to 300,000 cpm and controlling any number of operations.

CIRCLE 80 ON READER-SERVICE CARD

SCIENTIFIC AND PROCESS CONTROL INSTRUMENT INDUSTRIES OUTLOOK FOR 1961 AND REVIEW OF 1960

SALES OF SCIENTIFIC AND INDUSTRIAL INSTRUMENTS are expected by the industry to increase in 1961 substantially over the $4.5 billion estimated for 1960, the Business and Defense Services Administration, U. S. Department of Commerce, reports. Although the level of capital expenditures by manufacturing industries and public utilities in 1961 is expected to approximate the 1960 level of $20 billion, increased sales of industrial instruments are anticipated.

Background

Scientific and process control instruments are used to indicate, record, and/or control electrical, chemical, and physical quantities. This definition excludes machinists' precision tools, such as calipers, micrometers, and gage blocks; slide rules; drafting and plotting instruments; and templates.

The industry is a multifirm, multiproduct complex of several thousand manufacturers that make more than 100,000 catalogued devices used in measuring and controlling electrical, chemical, or physical properties.

This group of industries has grown at the prodigious rate of 11% annually since the end of World War II. If this progress continues, sales of scientific and industrial instruments will triple every 10 years,* and will probably increase faster than 11% annually in the next 15 years.

The post-World War II expansion, characterized by increased application of instrument principles to production technology, has been enabled by the producers' great strides in extending the range, precision, sensitivity, and applicability of instruments. The speed of this technological growth is attested by the fact that more than 50% of the instruments on the market today did not exist 10 years ago.

The growth of R&D activities, now regarded as a service industry, has contributed to the scientific instrument industry's development. Rapid increases in R&D laboratories have stimulated sales of instruments associated with research and development. Another stimulus has been the increased use of equipment in which instruments are incorporated as components, such as aircraft, missiles, marine vessels, missile-control systems, navigational and landing aids for aircraft, and telemetering systems. The complexity of instrumentation in such end equipment, particularly flight control and ground support systems, has been increasing.

For the purpose of estimating sales, scientific and industrial instruments are divided into the following categories:

Scientific instruments—Used in such fields as research and development, meteorology, geophysics, astrophysics, and astronomy.

Industrial instruments—Employed in industrial processes for measuring and/or controlling variable elements and conditions, or for testing materials, parts, assemblies, and products at various stages of manufacture. In this report, instruments used by electric and gas utilities are classed as industrial instruments.

Component instruments—Furnished as components of equipment in which they become an integral part of the equipment. This breakdown does not denote differences in operating principle, design, or precision of instruments; many instruments used in scientific pursuits are identical in these respects to those employed in industrial processes and/or as integral components of end equipment.

The terms "scientific" and "industrial" do not have the same connotation as when applied to the Standard Industrial Classification or the Census of

---

Report by United States Department of Commerce, Frederick H. Mueller, Secretary, Washington 25, D. C. Business and Defense Services Administration; Scientific, Motion Picture, and Photographic Products Division

*Instruments Publishing Co. has estimated growth rate of instrument industry as 100% every 5 years.

Manufactures; therefore, they should not be identified with SIC Industry 3811—Engineering, Laboratory, and Scientific and Research Instruments and Associated Equipment, or with Census Product Code 38213—Industrial Process Instruments.

The SIC and Census industry classifications group together functionally related products. Thus, slide rules, drafting instruments, and templates are included in SIC industry 3811, missile guidance systems in SIC industry 3662, and electronic industrial controls in SIC industry 3622. This report covers all scientific, industrial, and component instruments, regardless of their Standard Industrial Classification grouping.

The breakdown used here is made necessary by the availability of specific statistical indicators that are closely related to the sales of scientific industrial, and component instruments. These are, respectively, expenditures of additional research and development facilities; expenditures for new plant and equipment; and shipments of end equipment for having instruments as integral components.

Trends in 1960

Scientific instruments—The Federal expenditures of $450 million for new R&D facilities in 1960 represents a decline of about $100 million below the 1959 level. This was offset by a rise in private industry's outlays for such facilities from about $575 million in 1959 to around $680 million in 1960, and by an increase to approximately $1.5 million in Government expenditures for meteorological instruments.

Industrial instruments—Capital expenditures by manufacturing industries and public utilities are expected to total about $20 billion in 1960, an increase of about $3 billion over 1959. The proportion of these expenditures going toward replacement and modernization of equipment rose from 63% in 1959 to 69% in 1960.

A particularly important development in 1960 was the increased automation of on-stream process analysis and control. Appreciable advances were made in computer-controlled processes, resulting in an increase in the number and complexity of measuring and control devices in particular processes.

Component instruments—Government expenditures for aircraft in 1960 declined by about $1 billion from the 1959 level, to about $6.5 billion. The drop was partially offset by an increase of $500 million in purchases of commercial aircraft, to $1.5 billion. Government outlays for missiles are expected to reach about $3.7 billion in 1960, up $200 million from 1959. Federal expenditures for commercial aircraft navigation aids amounted to $118 million in 1960, up about $36 million over 1959. Department of Defense spending for electronics and communications will likely reach about $1.2 billion, an increase of about $300 million.

Total sales—Sales are expected to reach $4.5 billion in 1960, representing a 15% increase over the $3.9 billion estimated for 1959.

The 1961 Outlook

Scientific instruments—Federal outlays for new R&D facilities are expected by the industry to be around $500 million in 1961, $50 million greater than in 1960. Such spending by private industry is expected to be about $800 million, an increase of $120 million over 1960. Government purchases of meteorological, geophysical, and similar scientific instruments are expected to increase in 1961 about $2.7 million.

Industrial instruments—Capital outlays by manufacturing industries and public utilities are expected to approximate the 1960 level of $20 billion, according to industry sources. However, the proportion spent for instruments will probably be greater in 1961 than in 1960, for the following reasons:

The manufacturing industries as a whole are operating at about 80% of the preferred rate of capacity, the range for individual industries being from about 50% in the case of steel, to 90% for the paper and pulp industry. This level of operation indicates that the major portion of capital outlays be devoted to new equipment and modernization. Thus, a decline of 10% in capital outlays by the steel industry in 1961, for example, would not necessarily indicate a decline in the steel industry's demand for instruments.

Although fairly large decreases in capital spending reportedly may be expected in the case of the steel, paper and pulp, metal working, and other industries, they will be offset by increase in capital outlays by the petroleum, chemical, and food and beverages industries, and the public utilities. These are industries in which a relatively high instrument-to-equipment cost-ratio prevails.

The trend toward increased automation in process control, especially in computer-controlled systems, is expected to continue. The industries that are expected to increase their 1961 capital outlays over 1960—chemical and petroleum refining, as well as public utilities—are those whose processes are best adaptable to computer control.

Component instruments—The industry expects that spending for aircraft and missiles by the Department of Defense (D.O.D.) will be maintained in 1961 at the 1960 levels—$6.5 billion and $3.7 billion, respectively. Nor is any change expected in D.O.D. expenditures for electronic and communications equipment, which amounted to $1.2 billion in 1960. Purchases of commercial aircraft are also expected to remain at the 1960 level, $1.5 billion. Federal expenditures for commercial air traffic and navigational aids are estimated at $165 million in 1961, an increase of $47 million.

Total sales—A moderate increase is expected by the industry in sales of scientific instruments, a sharp rise in industrial instruments, and a small increase in component instruments, for an overall substantial increase in 1960 over the $4.5 billion estimated for 1960.

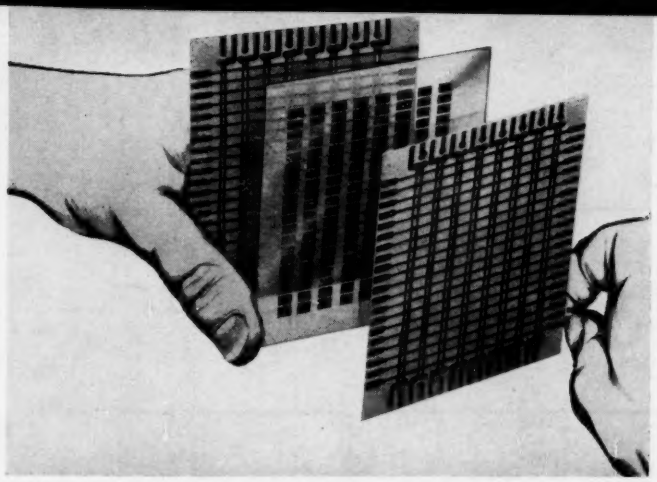


FIG. 1. EACH PLANE of a thin-film memory is sandwiched between two printed circuits containing the conductors for the drive (clock), write (information), and read (sense) currents. This plane has 20 x 8 bits, can store 20 8-bit words.

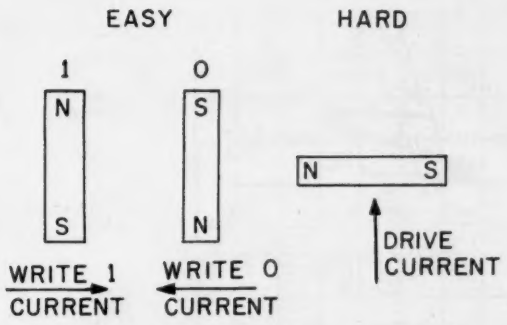


FIG. 2. EACH THIN-FILM element can be magnetized to behave like a magnetic dipole. The dipole can be made to have a better B-H characteristic in one direction (preferred or "easy" direction). Drive current in direction shown causes polarity of magnetization to be in "hard" direction. Write current, in directions shown, causes polarity to take the "preferred" 0 or 1 direction.

Thin-Film Memories

Thin-film memories offer advantages of high speed of operation, low cost of fabrication, and simplicity of design. Their versatility in size, shape, and connector arrangements makes them attractive devices for the computer and data storage fields. Here are the principles, operation, features and construction techniques for thin-film memories.

ERIC E. BITTMANN
Burroughs Corporation
Burroughs Laboratories

STORAGE ELEMENTS in the thin-film memories to be discussed are planar 80-20 Ni-Fe films less than 5000 Angstroms thick. They are obtained by vacuum deposition or by electroplating the Ni-Fe alloy onto a suitable base. These thin films can be magnetized rapidly (in the nanosecond range); memories with cycle times of 0.2 μsec, or less, are possible. High speed and low cost make thin films a desirable memory device.

Operating Characteristics

Any magnetic material with a square-loop B-H characteristic can be used as a storage element in a random-access memory. Behavior of thin-film memories can be compared with a magnetic dipole (Fig. 2). The two states of the dipole represent the storage of a "1" or a "0" in each thin-film element.

Films deposited on a substrate while under the influence of a magnetic field of 10 to 50 oersteds have a square B-H characteristic parallel to the axis of the dipole, as shown in Fig. 2. This is called the "easy" or preferred direction of magnetization. When the film is magnetized in a direction perpendicular to this easy direction, the film B-H characteristic is as shown in Fig. 3. This is known as the "hard" direction, shown in Fig. 2.

The principle of operation is as follows: The film element is magnetized in the "hard" direction by a *drive current*. A second current (write or information current) on a separate wire causes the direction of magnetization to swing into one of the two "preferred" polarities (Fig. 2). This is the recording process for a 0 or 1 bit.

The directions of the drive and write currents are shown in Fig. 2. Note that the conductors for these currents must be perpendicular.

To magnetize a selected area of thin-film to the 0 or 1 state, two magnetic fields, perpendicular to each other, are applied—the drive field in the "hard" direction and the information field in the "easy" direction. When both currents are applied, the resultant field lies between the hard and easy directions, oriented toward either 0 or 1 (depending on the direction of the write current). Upon

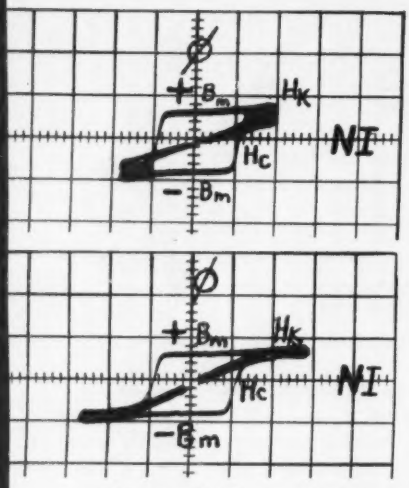


FIG. 3. **B-H characteristic** in the "preferred" (top) and "hard" directions (bottom). Square and linear loops are superimposed. Note that more drive must be applied to lower system, causing opening of the linear loop.

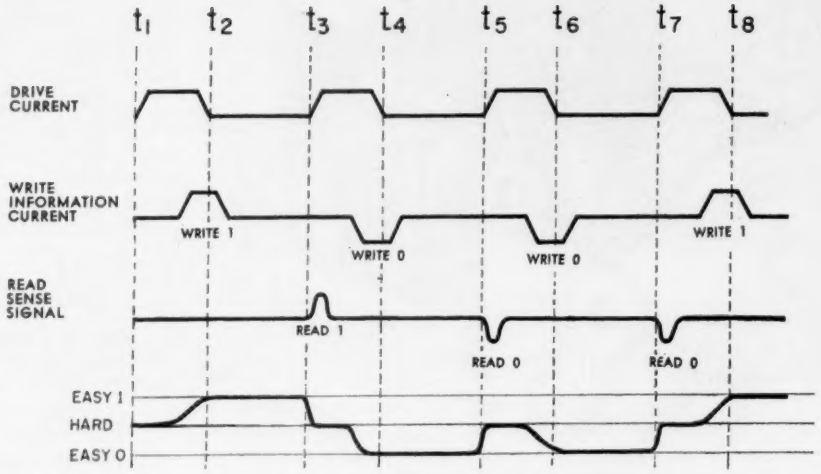


FIG. 4. **IN OPERATING** a thin-film memory, the drive and write currents must be timed so that they overlap, with the former leading. When drive current is on (t_1), bit is magnetized in "hard" direction. When drive current goes off (t_2), write current causes element to assume the easy "1" polarity.

removal of the drive field, the write current causes the dipole to assume the desired 0 or 1 state, depending on the direction of the write current.

In Fig. 4 the drive current goes on at t_1, off at t_2, on at t_3 etc. When on, it causes the bit to be magnetized in the hard direction.

The write current comes on before the drive goes off, and continues after the drive goes off. Thus, each time the drive goes off, the remaining write current establishes the polarity of the bit—0 or 1. For example, at t_2 the bit goes to the 1 state; at t_4 the bit goes to the 0 state.

For reading, a third (sense) conductor, parallel to the write conductor, senses the polarity of the bit each time the drive (clock) pulse arrives. In effect, each element is interrogated (destructively) by each drive pulse.

This is shown by the third and fourth lines in Fig. 4. At time t_3, the change in polarity of the bit caused by the drive current induces a positive pulse in the sense (read) conductor.

At time t_5, the drive pulse causes the polarity to change in such a way as to induce a negative pulse in the read conductor, indicating that a 0 bit had been in the element.

Similarly, at t_7 the drive current indicated that a 0 bit had been in the element at the previous clock pulse.

Linear-select Thin-film Memories

Available memory planes (Fig. 1) have 20 x 8 bits (rectangles). These planes are sandwiched between two printed-circuit boards (each ten mils thick), which contain 20 drive conductors and eight sense and information conductors. Each rectangle has a dimension of 3/16" by ⅜" and gives a signal output of 5 mv when driven by 1-ampere pulses of 0.04-μsec rise time. This memory plane can store 20 words at eight bits per word.

Four planes can be interconnected in a memory that will store 80 words (Fig. 5). The 80-word (drive) lines can be connected to a selection matrix (a diode matrix, for example) so that only one word in each plane is interrogated at any one time. The information lines connect to information drivers, and the sense lines to sense amplifiers.

A word line that has been selected by the diode matrix will receive a full drive-current pulse. This current will interrogate a row of eight thin-film elements. The rotational switching of the magnetic state of each film then will induce a signal in its associated sense (read) conductor. The amplified sense signal is gated with the clock pulse (Fig. 4), and the output of the gate either sets or resets the associated flip-flop in the memory-information register.

Meanwhile, the drive current is still on. Before it can be terminated, an information-current (write) pulse must be sent through each of the eight information conductors. The polarity of each of the eight information currents is controlled from an associated flip-flop. This flip-flop controls the writeback of information into the selected row, or word, that has been read.

The unselected rows of memory bits are subjected only to this information (write) field, and if this field is kept small enough (smaller than H_c, the film's wall coercive force), no stored data will be lost.

The driving scheme described can be modified.

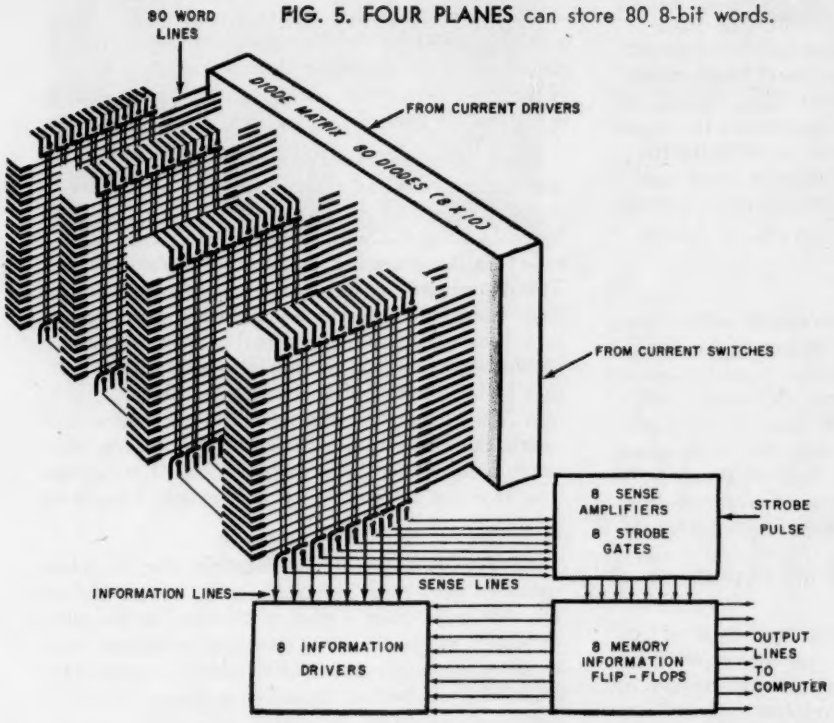


FIG. 5. FOUR PLANES can store 80 8-bit words.

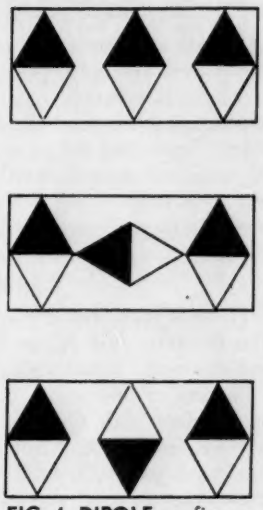


FIG. 6. DIPOLE configuration in nondestructure thin-film readout (NDR). Top shows dipoles in single domain; center, when drive field is applied; bottom, new arrangement after drive is removed.

Because the readout of information occurs during the leading edge of the drive current, and the writing of information during the trailing edge, the drive current can be replaced by two short pulses—one occurring during the leading edge, and one during the trailing edge, of the pulse. This method saves power in the transistors.

Instead of a bipolar information current, a d-c bias and a single-polarity current of twice the amplitude can be used. Absence of information current pulses insures the write-back of a zero into the selected film. (It might be more economical to design single-polarity-current drivers.)

The operating speed of such a memory is limited by the drive-current rise and fall times, and by the delay in all the selection circuitry, sense amplifiers, flip-flops, and drivers. Such memories presently are operated with a 0.2-μsec cycle time.

Coincident-current Thin-Film Memories

In the development of thin-film memories, one of the first ever described was a coincident-current type.[4] Here, operation is identical to that of a coincident-current core memory.

For coincident current, the drive fields are applied parallel to the preferred direction of magnetization. But noise induced in the sense conductor is hard to eliminate because of the parallel relationship of the sense and drive conductors. Also, switching time for the films is short (even if the switching is predominantly a domain-wall type) and the current rise-time induces sufficient noise to obscure the signal.

Considering these shortcomings, coincident-current techniques are not presently good enough. Word-select-type memories give more satisfactory results.

Non-destructive-Readout Thin-film Memories

A non-destructive readout scheme, in which only a small drive field in the hard direction is applied to a single-domain thin film, has been described.[5] In this method the field rotates the dipole some degrees away from the preferred (easy) direction, but not the full 90°. After the drive is removed, the dipole rotates back to its original state.

Investigators tested portions of large areas of films (rather than small individual spots) in that mode of operation. They found that stored information cannot be read out an indefinite number of times, even when the drive field is small. It was observed that the readout signal amplitudes decreased after many readouts, and that there was a tendency for the readout signals to reverse their polarity.

This behavior is illustrated in Fig. 6. If a single-domain film is represented by three (instead of one) dipoles, and if the center one is rotated 90° by a drive field and then left on its own, it will fall to its opposite state. (The dipoles on each side of the center one are magnetized to the opposite state.) Readout fields applied only to the center dipole cause it to rotate to the hard direction, but upon removal of the field, the dipole falls back to its original state. This type of non-destructive readout is quite satisfactory.

Domain Structures Observed

Domain structures in thin films can be observed with a Kerr magneto-optic apparatus.[6] Here, polarized light is reflected from a thin film. The plane of polarization is rotated a few degrees to the right or left, depending on the magnetic state of the film. Domains will appear as either white or black areas, and areas magnetized in the hard direction will be grey.

Circuits

Three types of circuits are associated with a thin-film memory—the driver, the information (write), and the sense (read) amplifier.

Drivers. Fast-current drivers, delivering 1-ampere pulses with rise and fall times of 20 nanoseconds, can be constructed with the high-speed transistors presently available. Both PNP and NPN transistors are used, especially when word-selection occurs in a diode matrix. The information driver has to deliver less current than the read drivers, and bipolar drivers with NPN and PNP transistors are easily designed.

Sense Amplifier. The sense amplifier is of the differential type. It rejects the common-mode noise signal. The sense and information conductors of neighboring memory planes are interconnected in a noise-canceling fashion by reversing the sense-conductor connections.

Thin-Film Fabrication

Several techniques have been tried for the fabrication of thin films. Successful results have been obtained in each of the following methods:

Evaporation. In this method,[1] Ni-Fe is transferred to a hot, dielectric substrate in the presence of a magnetic field of 10 to 50 oersteds. The substrates, usually glass, are chemically cleaned before they are inserted into the vacuum chamber. The substrates are placed 5″ to 10″ from the evaporating source, and are heated, by a substrate heater, to 300 to 350°C.

The raw material can be placed either in a crucible or onto a filament. The crucible contains the Ni-Fe alloy and is heated by an induction heater. But uniform depositions, by this method, can be obtained only over a small area. Either Ni-Fe or tungsten materials can be used as filaments. In the latter case, the Ni-Fe material is attached to the tungsten filament. Because of the versatility of filament arrangements, the filament method produces a more uniform evaporation over a larger area.

Evaporation through a mask produces the desired arrays. Insulators and conductors can be deposited in more elaborate systems.

Sputtering. The heated substrate is in an argon atmosphere, at reduced pressure. The Ni-Fe source is some distance away from the substrate and held at a positive electrical potential of about 500 volts. Argon gas ions are attracted to the positive source, and they hit it with sufficient energy to knock Ni-Fe molecules from the source. These molecules strike the surrounding substrate and coat it with a thin layer of Ni-Fe. The magnetic field present causes the desired preferred direction. As the rate of material deposition during sputtering is slow, it is difficult to control the process.

Vapor Deposition (Pyrolysis). Dried nitrogen gas is introduced in a chamber which contains a liquid solution of nickel-iron carbonyls. The gas becomes saturated with these carbonyls and is sent to a plating chamber containing the substrates. This chamber is heated inside an infrared oven. At these elevated temperatures the carbonyls decompose into a metal alloy and carbon monoxide. The carbon monoxide and the nitrogen are fully burned, in a Fisher burner, after leaving the plating chamber. The metal deposits onto the substrates and yields the desired thin films. The process is relatively simple and shows promise, but it is poisonous. It is not recommended in a simple laboratory setup.

Electrodeposition. Thin films can also be fabricated by deposition[2] of Ni-Fe alloy, onto a dielectric substrate, from a plating solution, in the presence of a magnetic field. The glass substrates have to be made conductive before plating occurs. One method is sputtering material on the substrates in sufficient quantity to insure conduction. In another method, silver or gold is sprayed on, or a chemical silvering process is used. The thickness of this conductive layer has an effect on the film; controls are needed to insure uniformity and reproducibility.

After the plating process is over, discrete bits can be arranged by etching out the unwanted material.

All of these fabrication processes—evaporation, sputtering, vapor deposition, and electrodeposition—have yielded usable thin films.

References

1. M. S. Blois, Jr., "Preparation of Thin Magnetic Films and their Properties," *Journal of Applied Physics*, Vol. 26, August 1955, Pages 975-980.
2. I. W. Wolf, H. W. Katz, and A. E. Brain, "The Fabrication and Properties of Memory Elements Using Electrodeposited Thin Magnetic Films of 82-18 Nickel Iron," 1959 *Proceeding of Electronic Components Conference*, AIEE or IRE.
3. C. Kittel, "Theory of the Structure of Ferromagnetic Domains in Films and Small Particles," *Physics Review*, Vol. 70, December 1946, Pages 965-971.
4. A. V. Pohm and S. M. Rubens, "A Compact Coincident Current Memory," 1956 *Proceedings of Eastern Joint Computer Conference*, IRE.
5. K. Chu and J. R. Singer, "Thin Film Magnetization Analysis," *Proceedings* of *IRE*, Vol. 47, No. 7, July 1959, Pages 1237-1244.
6. J. W. Hart, "Domain Behavior in Thin Magnetic Films," *Transactions*, 1960 *Nonlinear Magnetics and Magnetic Amplifier Conference*, AIEE.

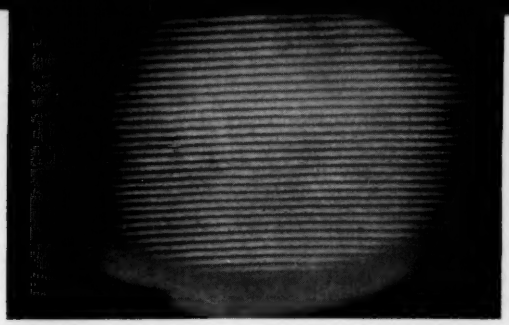


FIG. 1. NEWTON'S RINGS (interference fringes) between 2 optical flats, one of which is tilted with respect to the other. By placing a straight edge across the fringes one can see that the two flats are within 1/3 fringe of each other—that is, each line deviates from straightness by about 1/3 fringe.

TABLE 1—SCRATCH AND DIG CODE NUMBERS FOR SPECIFYING SURFACE QUALITY

	SCRATCH	DIG
Telescope Objective	60	40
Microscope Objective	30	10
Photographic Lenses	40	20
Eyepiece	15	10
Condenser Lenses	80	60
Mirrors	40	40
Reticles	10	5
Prisms	40	20

TABLE 2—ACCEPTABLE RING FRINGES.

USE	SPHERICITY RINGS	IRREGULARITY RINGS
Eye Piece	15	4
Telescope Objective	5	1
Condenser	gage fit	gage fit
Microscope Objective	5	1
Photographic Lenses	5	1
Mirror	2	1/2

OPTICAL SYSTEMS

MILTON LAIKIN
Beckman Instruments, Inc.

In the design of optical systems, important factors include glass type, striae, anneal, stain, and surface quality. Lenses, mirrors, spherical surfaces, and flats are discussed.

OPTICAL GLASS is specified by giving information concerning three major qualities—glass type, striae, and type of anneal.

1. *Glass type* is specified by a six-digit number.* For example: 517645 means

$$N_D = 1.517$$

$$V = 64.5 = (N_D - 1)/(N_F - N_C)$$

where N_D is the index of refraction for the Fraunhofer D line (5893 Angstroms) and V is the constringence of the material. Subscripts C, D, and F are the Fraunhofer C, D, and F lines, corresponding to wavelengths of 6562.8, 5893.0, and 4861.3 Angstroms, respectively.

2. *Striae* are index-of-refraction *variations* in the glass. Striae AA is used for very-high-quality mirrors and prisms; striae A is for high-quality mirrors and prisms; striae B for most lenses; striae C for condenser lenses. Use striae D only where refraction is not important; never in a mirror. (Very low striae are not required in a mirror because mirrors are not used to transmit light for much distance.)

3. Generally, *fine anneal* should be specified for lenses (except condenser), prisms, mirrors and windows. *Commercial anneal* should be specified for condensers, and where refraction and dimensional stability are not important.

Where the index and dispersion can be arbitrarily chosen (for mirrors, windows and prisms), 517645 glass is the best to use. This glass is in common use, is relatively cheap compared to other optical glasses, and the chemistry of the glass is such that it comes with smaller and fewer bubbles and is more stain-resistant than other optical glasses.

Pyrex

Pyrex is a low-coefficient-of-thermal-expansion glass, but the material has considerable striae, thus making it suitable only for condenser lenses and mirrors. In large sections it is considerably cheaper than any of the optical glasses. Its stain and chemical resistance is excellent and it is easy to optically grind and polish. It is thus the preferred material for first-surface mirrors.

Pyrex generally comes in two grades of annealing—commercial and fine. For condenser lenses, the commercial anneal is generally adequate. Use fine anneal for mirrors.

Stain

Certain types of glass stain quite easily, particularly the dense flint and rare-earth glasses. When using these glasses consult the manufacturer's glass catalogs to determine maximum stain permissible

*See Military Specification JAN-G-174. The numbers given in parenthesis as (JAN-G-174) refer to military specifications. However, these are really more than military specifications but rather represent common practice in the industry. The optical industry has accepted many of the procedures, requirements, and terminology as set forth in these military specifications.

Terminology

Refraction—Change of direction of radiation due to the different propagation velocity of energy in different media.

Index of Refraction (N)—Ratio of the sine of the angle of incidence to the sine of the angle of refraction when energy enters the medium from free space.

N_F = Index of refraction for wavelength of 4861.3 Angstroms (Fraunhofer F line).

N_D = Index of refraction for wavelength of 5893.0 Angstroms (Fraunhofer D line).

N_C = Index of refraction for wavelength of 6562.8 Angstroms (Fraunhofer C line).

Dispersion—Change in refraction due to frequency of radiation.

Fraunhofer lines—Lines in solar spectrum, as labeled by Fraunhofer in 1815.

Fraunhofer C line—Sodium vapor lines in solar spectrum.

Fraunhofer D and F lines—hydrogen lines in solar spectrum.

Dispersive Power—$(N_F-N_C)/(N_D-1)$.

Constringence—Inverse of dispersive power, a measure of quality of optical glass.

Striae—Variation of index of refraction throughout a material.

Dig—Bubble cut open in polishing.

Newton's Rings—Interference fringes.

First-surface Mirror—Mirror in which incident light strikes the reflecting surface first.

Second-surface Mirror—Mirror in which incident light passes through the first surface and is reflected from the second surface.

(none, light brown, medium brown, heavy brown, blue).

Generally, a light brown stain will be the maximum permissible in most optical systems.

Surface Quality

Optical elements usually are first formed roughly to shape at the glass plant by a method known as *pressing*. The optical glass is heated and then pressed into a die to the approximate shape.

The pressing is next roughed, ground, or milled. Flat surfaces are formed on a Blanchard grinding machine. Diamond milling with a cup tool is used to generate spherical surfaces.

In conventional grinding the glass is first blocked to a rotary spindle with pitch or, in special cases, plaster of paris. Starting with a coarse emery (#1) the operator proceeds through to finer emeries (#3). The optic is next polished with a pitch polisher and a polish, such as cerium oxide, zerox (zirconium oxide), barnsite, aluminum oxide, red rouge, or magnesium oxide.

Optical glass always has a few bubbles in it, and the polished surface will have digs due to the polished surface passing through a bubble. Scratches are caused by insufficient fine grinding or polishing, or by dust in the air which settled on the surface while polishing.

The designer should specify where the surface finish should be ground or polished. Non-optical surfaces, used for mechanical mounting only, should be left ground. A #1 grind (a coarse grind) is adequate if not used for mounting; #2 grind (a medium grind) is recommended for general mounting; #3 grind is a fine grind.

Optical surfaces should be polished. Here the designer specifies the scratch, bubble and dig by means of a code, per MIL-O-13830. This code number has two parts, the first of which represents the width in microns of the acceptable scratches, and the second of which represents 1/10 the diameter in microns of acceptable bubbles and digs. The scratch number is first, followed by the dig and bubble number. Hence 40-20 means maximum scratch width of 40 microns, and maximum dig and bubble diameter of 200 microns.

The permissible scratch and dig numbers can be determined only by noting the position of the element in the optical system, and the end use to which this system is to be put. Table 1 shows the code number for scratches and digs for various optical uses.

Inspection of parts for compliance with the scratch and dig code can be simplified by comparison to a plate engraved with the various permissible digs and scratches. However, there is no substitute for a well-trained inspector.

Thickness

The edge thickness of *positive (convex) lenses* should be at least 0.030″ for lenses under ¼″ diameter, 0.040″ for lenses up to 1″ diameter, and 0.050″ for lenses over 1″ diameter.

Make center thickness of *negative lenses* at least 1/10 the diameter.

Make thickness of *flat mirrors* 1/5 the diameter if the mirror is to be flat within 1/8 wavelength; 1/10 diameter if it is to be flat to within 1/2 wavelength.

The *free aperture* of an optical element is the optically used area—that is, that part of the element to which the optical specifications apply. For example, it generally requires 0.040″ all around a lens to properly support it. The scratch and dig code would not apply to this outer 0.040″ ring because it has no optical function. Free aperture is assumed (unless otherwise specified) to be of the same shape as the part and centered on it.

Surface Shape Tolerance

Flatness is the departure of the surface from an ideal plane. It is specified in wavelengths of light

of 5461 Angstroms, corresponding to the mercury green line which is in general use.

Flats are checked against a master optical flat. Newton's rings from a monochromatic light source are observed (Figs. 1, 2 and 3) generally while the work is still blocked. The sphericity (which shows up as rings of light) is noted and the work returned to the machine. The operator then makes the necessary adjustments to bring the work to plane.

Spherical surfaces are either made to a gage fit or a test-glass fit. In grinding the surface to shape, a brass gage is used to check surface sphericity. Gage-fit surfaces are generally adequate for condenser optics.

Test glasses are made by making two matching spherical surfaces. The surfaces are made truly spherical by comparing with each other and observing the Newton's rings. Radius is measured on an optical bench by locating the center of curvature on the concave glass. These test glasses are then used like optical flats to control surface shape. Two parameters must be specified—accuracy and irregularity, or sphericity. Accuracy is the number of rings seen when the test glass is placed on the work (Fig. 5). Irregularity is the departure of a ring from a true circle. This is the difference between the maximum number of rings across ½ the surface (counting from the center of the fringe pattern to the edge) and the minimum. 1 ring is ½ wavelength—10.9 millionths of an inch.

Although exact tolerances can be worked out only by ray-tracing, the ring counts given in Table 2 are helpful for general use.

Lens Centering and Trueing

After both lens surfaces have been polished, the lens is centered with respect to its edge. This is done by rotating the lens in a lathe-like machine and observing the reflection of a lamp from the lens surface. The lens is adjusted while rotating so that the reflected image appears stationary. This means that the line connecting the centers of curvatures of the lens faces is coincident with the axis of rotation of the lens. With the lens still rotating, a grinding wheel is used to bring the edge to the proper diameter. At this time a slight bevel is put on the edge to prevent chipping.

The lens designer should specify (Fig. 4):

1. Bevel; a 0.030″ face width maximum (only specify the maximum).

2. Lens diameter and tolerance; this is usually about ±0.005″.

3. Centering in terms of maximum edge run-out as lens is rotated. This is usually about ±0.005″ for most lenses, but may be as small as ±0.002″ for microscope objectives, and as large as ±0.010″ for condensers.

Centering and trueing also can be specified by indicating the half angle of swing of the optic axis of the lens with the edge running true. This generally will be from 1 to 10 minutes of arc. (Either method of specifying is satisfactory.)

FIG. 2. INTERFERENCE fringes between 1/4" plate and an optical flat, showing waviness of plate surface.

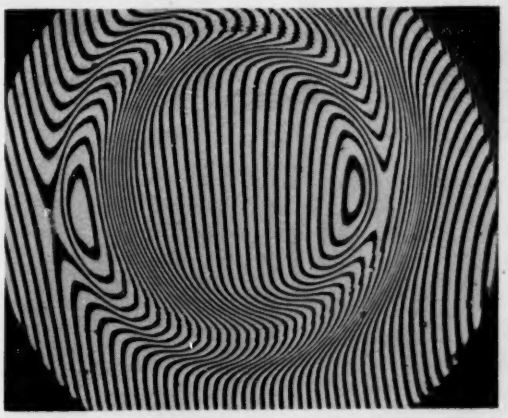


FIG. 3. INTERFERENCE fringes between an optical flat and a flat with a zone polished into it. The zone is six fringes deep.

Specify the lens radius in inches. Radius tolerance should not be less than 0.1% of the indicated radius. General practice for most optics is a ±2% tolerance. If radius is critical, then ±½% should do. For condenser lenses ±5% is adequate. Table 3 shows data for the lens in Fig. 4.

Cementing

Multi-element lenses are cemented after each element is edged. Before the cement sets, the elements are aligned to have a common optical axis. This is known as trueing. The designer specifies the maximum ½-angle of swing of the optical axis when the lens is rotated with its mounting surface running true. This trueing tolerance is generally between three and six minutes of arc.

The most common material for cementing optical parts is Canada Balsam, whose N_D is 1.540. By proper filtration this material can be made clean. It is convenient and economical but it has poor thermal and mechanical shock properties and exhibits plastic flow at room temperatures. For optical instruments subject to thermal and mechanical shock, and for military applications, a thermosetting optical cement (MIL-A-3920) should be used. This cement is satisfactory over the temperature range −65°F to +160°F; N_D is 1.55. A material meeting this specification is made by Summers Laboratories, Ambler, Pennsylvania, and is sold under the name "Lens Bond."

Where excessive mechanical shock is encountered, an epoxy cement will be helpful. Epon 815, catalyzed with 10% by weight of diethylene triamine (DTA), is available from Shell Chemical Company. Cure at room temperature for 24 hours.

Epon 815 and 12% curing agent D, cured at 70° C for 4 hours, is also useful.

Another material, producing a somewhat brittle but more transparent bond is Dow DER 332, available from Dow Chemical Company, Midland, Michigan. Mix with 18% by weight Oronite MXDA, available from Oronite Chemical Company, San Francisco, California. Cure at room temperature for 24 hours.

Anti-Reflection Films

Polished air-glass surfaces of most optical instruments are coated to reduce reflections. For zero reflection at a given wavelength of incident normal light the coating material should be ¼ wavelength thick, and the material should have an index of refraction equal to the square root of that for the glass.

The most common material for this purpose is *magnesium fluoride* (JAN M621*); N_D is 1.38. This material is evaporated thermally in a vacuum onto the glass and subsequently baked. The resulting coating (JAN F675) is quite hard and will withstand normal cleaning and handling.

Two-layer coatings also are used. A quarter-wave filter of zinc sulfide ($N_D = 2.28$) is first applied, followed by a quarter wave of magnesium fluoride.

In specifying coatings, the material and wavelength for minimum reflection should be specified.

Reflecting Films for Mirrors

A first-surface mirror is one in which the incident light first strikes the reflecting surface; in a second-surface mirror the incident light passes through the first surface and then is reflected from the second surface.

First-surface mirrors are generally aluminized by vacuum deposition (MIL M 13508). Such thin coatings of vacuum-deposited aluminum are soft and cannot be cleaned normally. It is customary to protect them with a half-wavelength of evaporated magnesium fluoride or silicon monoxide. Mirrors so coated and protected will have a reflectivity of from 86% to 90% in the visible range.

Freshly-deposited silver has high reflectivity—about 95% for green light. However, silver soon tarnishes and its use is limited to those applications where it can be protected from the atmosphere.

Second-surface mirrors are generally chemically silvered. Copper is then deposited electrochemically to protect the silver coating.

Prisms

Commercial angular tolerance on prisms is ±5′ arc. Angular tolerances as small as ±1″ arc can be achieved, but this becomes essentially a hand operation and results in high cost.

Glass should be 517645 fine annealed when a nondispersive system is desired. Specify Striae B.

A right-angle prism (45°-45°-90°) is used to deviate a beam of light through 90°. It contains three polished faces and two fine-ground edges. These edges are for mounting only, and one may simply specify "fine grind." The two right-angle faces should be flat to 1 wavelength for most applications and coated with magnesium fluoride at 5500 A. For 90° deviation the hypotenuse must never be coated with magnesium fluoride. Since it is a reflecting surface, it should be flat to ¼ wavelength. No coating is necessary because it reflects by total internal reflection.

*Military specification for this material.

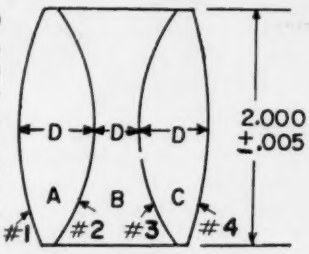


FIG. 4. SUGGESTED format for drawings. Only information necessary for manufacture should be shown; focal length, index of refraction, and optical properties should not be included.

TABLE 3—LENS SPECIFICATIONS FOR A MULTIELEMENT LENS (FOUR SURFACES AND THREE MATERIALS)

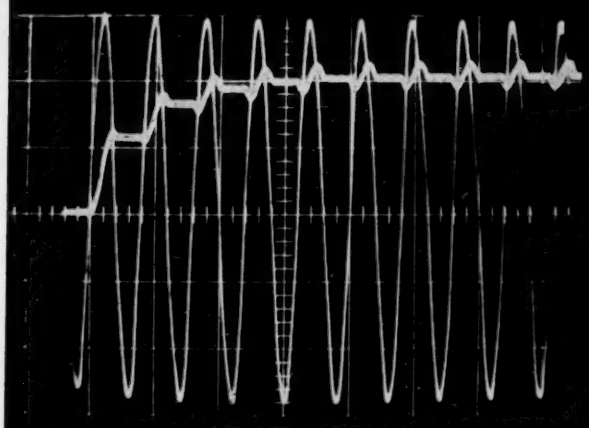
Surface	#1	#2	#3	#4
Radius*	4.000″	2.865″	2.500″	6.900″
Accuracy, rings	5	1	1	5
Irregularity, rings	½	1	1	½
Scratch No.	40	60	60	40
Dig No.	20	40	40	20
Coating	MgF_2**			MgF_2**
ELEMENTS	A	B	C	
Glass Type	517645	617366	517645	
Anneal	Fine	Fine	Fine	
Striae	B	B	B	
Dimension D	0.730″ ±0.005″	0.410″ ±0.002″	0.620″ ±0.005″	
Free Aperture	1.920″			
Center Elements	1 min. arc			
True Assembly	1 min. arc			
Cement	Lens bond			

Break all Edges 0.030″ face width max.
*±½% of indicated radius
**¼ wavelength at 5500A

FIG. 5. TEST-GLASS pattern of 6-3. The work is accurate to the test glass within 6 fringes; it is 3 fringes irregular.

AC MEASUREMENT

FAST AND PRECISE

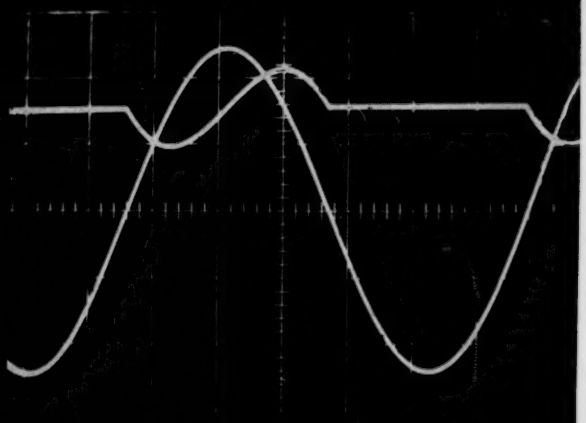


FAST ACQUISITION

Superimposed input and output waveforms show the fast response time of Adage's Type ACS1 AC Averager. Short filter time constant allows the steady state value to be achieved quickly.

PRECISE MEASUREMENT

The ripple present in the output waveform does not interfere with the precision of the measurement. Timing circuitry insures that the voltage measured is that value present during the interval when the output is ripple free.



Modern instrumentation systems demand equipment to make fast, precise measurements of AC signal waveforms. This required combination of speed and accuracy is beyond the capability of conventional techniques. For example, a conventional diode-capacitor AC/DC converter requires at least three seconds settling time to make 60 cps measurements. When many different signal sources must be scanned and measured successively, this slow response time limits seriously the overall system speed.

Slow response time is also a disadvantage in AC carrier systems. The transformer-driven diode bridge demodulators conventionally used as phase-sensitive AC measurement instrumentation for these systems have inherent limitations in both speed and accuracy. They tend to compromise the performance of instrumentation systems using them.

There has been, then, a clear need for innovation in the field of AC measurement. Responding to this need, Adage has developed several new AC measurement techniques. Among these is the fast-averaging technique illustrated in the accompanying waveform photographs. This technique offers substantially improved performance both for self-synchronous and phase-sensitive measurements. Response time, for example, is improved by more than a factor of ten to one. Used in conjunction with precision voltage to digital converters, modules implementing these new measurement methods have been successfully applied in many industrial and military instrumentation systems. A typical solid-state, AC Signal Conditioner is comprised of three 5" x 8" epoxy fibreglass circuit modules, easily incorporated in any of the Adage VOLDICON® voltage to digital converters.

Applications notes and technical data describing in detail Adage's AC instrumentation capability is available upon request.

Adage INC

292 MAIN ST., CAMBRIDGE 42
MASSACHUSETTS

West Coast Facility: 1145 East Ash Avenue, Fullerton, California

CIRCLE 81 ON READER-SERVICE CARD

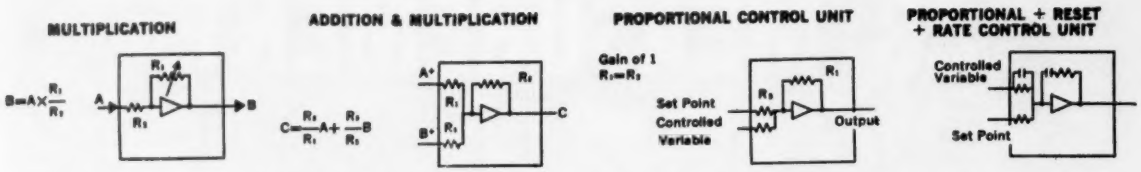


FIG. 1. OPERATIONAL AMPLIFIER uses resistors, capacitors and feedback to perform addition, subtraction or multiplication by a constant; or control by proportional, proportional plus reset, or proportional plus reset plus rate action.

DONALD T. CUSACK Hagan Chemicals & Controls, Inc.

Why Hagan Uses DC-Voltage

THE PRIME CONSIDERATION for a control system is reliability. This factor directed Hagan to the use of an all-solid-state control system, using operational magnetic amplifiers as the nucleus. The use of magnetics permits greater tolerance to ambient conditions, greater circuit flexibility, optimum linearity, and maximum open-loop gain. The use of d-c voltages takes full advantage of the operational-magnetic-amplifier technique with its inherent ability to produce any conceivable control action. Finally, when the entire amplifier is potted in epoxy and encased in a steel case, the package is virtually unaffected by its environment.

Ten year's experience* in the design of high-performance electronic control systems through analog-computer studies and control system designs (for Pratt & Whitney, M.I.T., Naval Supersonic Laboratory, Wright Air Development Center, Arnold Engineering Development Center, etc.) led to the development of *pressure* and *differential-pressure transducers* with accuracies of 0.1% of full scale and frequency response up to 40 cps. The associated amplifiers, controllers and electrohydraulic valve operators then were designed to take advantage of the transducer performance.

Industry needs *flexibility of control.* In a typical power plant, for instance, there are many interdependent varibles (interlocking control loops, wide parameter turn-downs, signal compensations and biasings). The operational amplifier (Fig. 1) is an amplifier with relatively high gain and (with negative feedback) can add, subtract, multiply, divide, ratio, bias, auctioneer, differentiate and integrate signals—all by using the basic amplifier with various resistor and capacitor arrangements.

The easiest method to provide the flexibility of accepting many signals to achieve the optimum of operational-amplifier techniques is to use *voltage* signals. The basic analog-computer approach, using voltage inputs, allows the handling of sophisticated control loops as well as single loops. This is another strong consideration for d-c *voltage* systems.

Comparison of Pneumatic and Electronic Systems

To illustrate the flexibility of the magnetic-operational-amplifier approach, compare the pneumatic and electronic circuits for a three-element feedwater control system.

Fig. 2 shows the pneumatic system. The linear pneumatic signals received from the steam and water flow transmitters are fed to opposite ends of a balancing relay. Another fixed signal is fed to a third chamber of the balancing relay so that the relay has an output signal, for instance, of 9 psi (mid-range of a 3 to 15 psi signal system) when the signals from the water and steam flows are balanced. The output signal of the balancing

* This experience dictated that the design of each element in the system complement the performance of the others in the control loop. It is NOT sufficient to take proven pneumatic transducers, substitute wires for copper tubing, and achieve optinum performance from electronic controls.

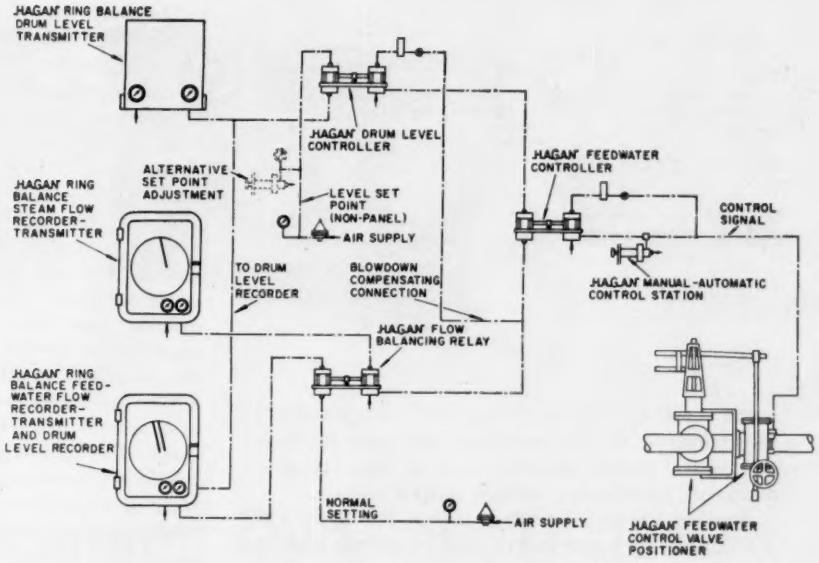

HAGAN RING BALANCE DRUM LEVEL TRANSMITTER
HAGAN DRUM LEVEL CONTROLLER
HAGAN FEEDWATER CONTROLLER
ALTERNATIVE SET POINT ADJUSTMENT
HAGAN RING BALANCE STEAM FLOW RECORDER-TRANSMITTER
LEVEL SET POINT (NON-PANEL)
AIR SUPPLY
CONTROL SIGNAL
TO DRUM LEVEL RECORDER
BLOWDOWN COMPENSATING CONNECTION
HAGAN MANUAL-AUTOMATIC CONTROL STATION
HAGAN FLOW BALANCING RELAY
HAGAN RING BALANCE FEED-WATER FLOW RECORDER-TRANSMITTER AND DRUM LEVEL RECORDER
NORMAL SETTING
AIR SUPPLY
HAGAN FEEDWATER CONTROL VALVE POSITIONER

FIG. 2. HAGAN Type BC-3 3-element feedwater control system, using pneumatic technique.

Control Signals

relay is the process variable signal to the feedwater controller, and is also the signal on the reset chamber of the drum-level controller.

The drum-level transmitter signal is sent to a proportional and reset controller whose output signal is 9 psi when the drum level is on control (and when the steam and water flow signals are balanced). The output of the flow-balancing relay biases the drum-level controller through the reset chamber, and establishes a "neutral" output when water level is at the desired point.

This is done because the reset time-constant on the conventional proportional-plus-reset drum-level controller would be too high to maintain stability in the cascade system. On manual control, reset response would shift the proportional band to one extreme or the other, and it would be necessary to manually adjust the drum level into the proportional band before making the transfer from manual to automatic operation. This system gives stability, good speed of response, and accurate drum-level control.

With the Hagan electronic control (Fig. 3), the same thing is accomplished simply by accepting the drum-level, steam-flow and water-flow transmitter signals as voltages, and feeding them into magnetic-amplifier controllers. On manual operation the controller is biased to prevent windup, as shown.

In systems where blowdown compensation* is

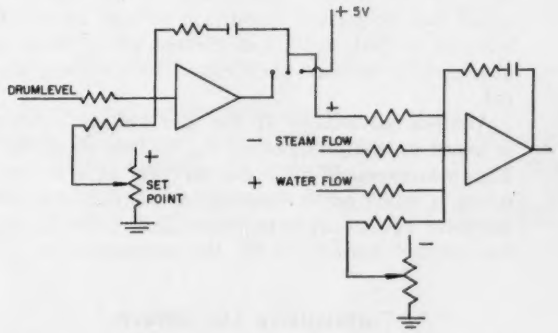


FIG. 3. POWRMAG 3-element feedwater control system, blowdown compensated.

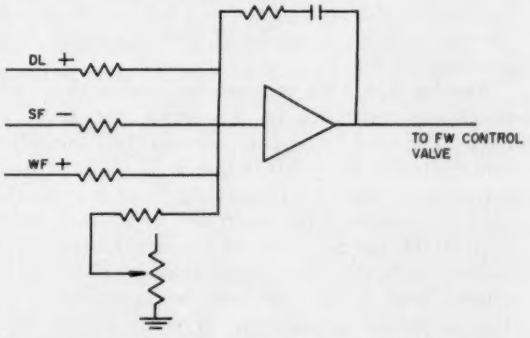


FIG. 4. POWRMAG 3-element feedwater control system, nonblowdown compensated.

not needed, this would reduce the electronic system even more, as shown in Fig. 4.

There are other reasons for using d-c *voltage* signals. Electronic systems find great use when loggers or computers are part of process control loops. The use of d-c voltages for transmitters as well as controllers fits neatly into the logger and computer system since these devices have standard input

* Blowdown refers to the continual draining of the drum to remove sediment. Variations in blowdown rate require an adjustment of drum level. The blowdown compensation readjusts the drum level.

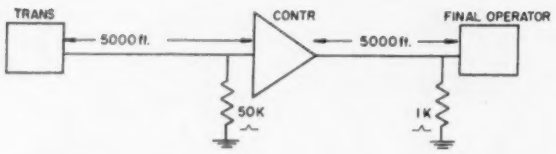


FIG. 5. **OPEN-LOOP** system, showing impedances.

circuits set up for accepting d-c voltages. Also, the increased use of end-point analyzers fits into the control system because most of these process analyzers provide d-c *voltage* output signals.

Another important feature is that this system is compatible with any direct *current* system that is now on the market. The transducer milliampere signal can be passed through a resistor of a size selected so that at 100% of current signal there is developed 9 volts dc, the desired 100% *voltage* signal.

Another advantage of the d-c voltage system is found in trouble-shooting and system check out. The measurement of a d-c voltage with a voltmeter is much easier than current signals with an ammeter because it is not necessary to break into any control lines to check the measurement.

Transmission Line Effects

It is commonly stated that the resistance effects due to long transmission lines (and to line changes because of ambient temperatures changes) are a problem in d-c voltage systems but not in direct-*current* systems. Consider a typical control loop as shown in Fig. 5.

Assume #18 AWS transmission wire with an approximate resistance of 6.4 ohms per 1000′ at 68°F: The total resistance between the transmitter and controller for a 5,000′ line is 32 ohms in each direction, a total of 64 ohms. As there is a 50,000-ohm impedance at the controller, 64 ohms in series with 50,000 has no effect on the signal when using factory-calibrated transducers that are fixed at the output load levels that will be encountered on the particular application. If even longer lines are present, this inaccuracy can be reduced further by using 100K ohms input resistance to the magnetic amplifier-controllers, without in any way affecting the controller performance.

If the temperature increased from 68°F to 122°F, the resistance of the transmission wire at 122°F would be approximately 7.14 ohms per 1000′. Assuming that the transducer was previously balanced at 68°F, the resistance change due to the temperature effect would be (7.14—6.38)x(5)(2), or a total resistance change of 7.5 ohms out of 50,000 ohms. This error is insignificant and the temperature effect can be neglected.

However, on the transmission lines from the controller to the final actuator, the problem appears a little more severe because there is a possible minimum 1000-ohm load and the error looks more significant. Using the same calculations as before, a temperature swing of 68°F to 122°F can produce an error of 0.75% for a 5000′ line. However, the closed-loop action of the controller will eliminate this error, because with a proportional and *reset* controller the feedback loop will compensate for any line loss and return the process to the set point. (In an application with long transmission lines and wide temperature excursions, reset-action should be recommended.) Therefore, the so-called advantage of direct-current systems where line losses due to resistance effects and temperature do not attentuate the signal, is a purely theoretical advantage and has no practical merit.

Direct-*current* systems do not have the line-drop resistance problem *as long as the total load on the system remains within certain limits.* However, because they operate in low-impedance circuits, the number of devices that can be hung on the loop, and the length of the transmission lines, are limited. If the transmission lines are long, the number of recorders and controllers that can be fed by one transducer is reduced. In a d-c *voltage* system, however, many high-impedance recorders or controllers can be accepted across the line. The pressure transducers, for example, are capable of balancing any external loads down to 7000 ohms. For instance, if there is a 50,000-ohm input impedance to the controller, seven other devices of similar impedance could be hung across the line without any signal attentuation. Similarly, with a 100,000-ohm impedance to the controller, 12 other 100K loads could be hung across the unit.

The use of d-c *voltage* systems with high impedance also has advantage in those instances where a poor terminal connection would add additional series resistance in the control loop. These resistances are normally low and would have no effect on voltage systems. However, in the low-impedance current systems, additional resistance can materially affect the signal.

In summary, therefore, the d-c *voltage*-signal approach allows maximum use of the operational amplifier technique and allows accepting d-c voltages from other devices, while transmitting signals to loggers and computers in the simplest, most reliable manner. In using *voltage* systems, there is no significant attenuation of signal due to length of transmission lines, or temperature effects of the lines themselves.

Bibliography

1. Nelson, Robert L., "Factors Influencing the Design of a Solid State Analog Control Systems," Hagan Chemicals & Controls, Inc.
2. Hicks, Fred, "Instrumentation of a New Steam Generating Facility," Weirton Steel Company. Hagan Chemicals & Controls, Inc.
3. Michaels, Franklin; Rouvalis, George, "Design Studies of Large High Performance Pressure Control Systems," Hagan Chemicals & Controls, Inc.

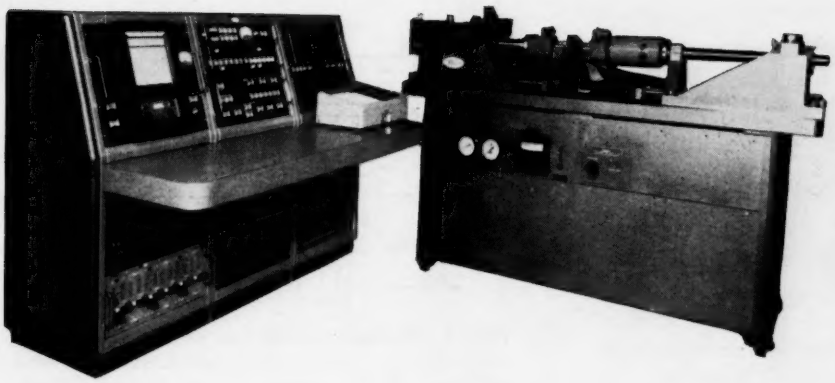


FIG. 1. MARQUARDT TM-1. Test Machine, one application for the programmer.

Programming Dynamic Tests

Programming often requires rapid and arbitrary changes in variables according to a desired program. This dynamic programmer uses a Vernistat Adjustable Function Generator as its programming heart, and can program tests over arbitrary combinations of strain and temperature.

G. B. KUBICECK
The Marquardt Corporation

HUMAN CONTROL cannot provide the smooth rapid changes in variables required in complex tests where characteristic system requirements include (1) rapid change of program, (2) ability to change program during the program run, and (3) wide range of sweep rates (time bases). Such problems are encountered in wind-tunnel tests, component tests, tensile tests, etc.

Cams, conductive lines on paper, wires glued to paper, photoelectric scanners, digital programmer and other techniques, including commercial function generators, were examined in a feasibility study made by the Air Force/Marquardt jet laboratory, Van Nuys. This resulted in an entirely new programmer design using an Adjustable Function Generator and Vernistat components in an automatically controlled system.

Programmer

The Marquardt Automatic Programmer (Figs. 2 and 3) is basically a variable voltage device whose output voltage is proportional to the vertical displacement of manually-positioned sliders on a grid (one for each channel). Each slider is contacted in sequence by a motor-driven Vernistat. The output voltage thereby varies in accordance with the position of each slider as a function of time. This grid system permits rapid setup of the program, visual presentation of the entire program. It even allows modification of the program while the program is underway.

A thyratron-controlled d-c motor with tachometer feedback provides precise control of the system sweep rate (time base). The motor, through a gear system, drives (1) the interpolating Vernistats (one for each channel), (2) a rotary switch used for automatic time cycle control, and (3) a rotary switch for sequential energization of indicator lights to provide visual indication of program progress.

Automatic time-cycle control provides (1) "one-cycle" or "continuous cycling" operation, (2) "cycle-to-start" or "hold-end-point" operation, (3) a sweep rate change for operator-selected rates at any point in the program.

The time base is continuous variable between 34 seconds per cycle to at least 3400 seconds per cycle. In practice, reliable motor speed control has been obtained at 6800 seconds per cycle, although the motor control specifications will not guarantee this.

*Perkin-Elmer Corp., registered tradename.

FIG. 2. PROGRAMMER has light under each contact to indicate horizontal position of sweep.

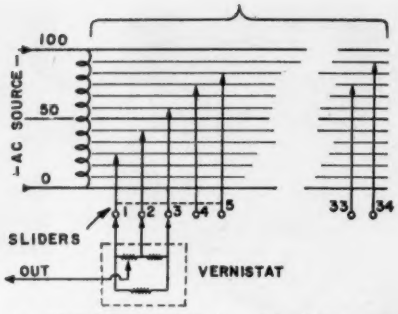


FIG. 4. PROGRAMMER has 34 sliding contacts, each of which can be positioned to make contact with any of 101 contacts on the tapped voltage divider.

The programmer (Fig. 4) has a printed-circuit grid consisting of 101 parallel lines which are connected to 101 taps on an accurate voltage divider (tapped coil or tapped resistance). Thirty-four sliding contacts can be independently moved perpendicular to the grid lines so that each slider can contact any one of the 101 grid lines. The result is a 101-position 34-pole switch. Since the grid lines provide 1% voltage increments, any voltage equal to or less than the input voltage can be selected by any slider to within ±0.5%.

Fig. 4 shows the programmer. The 34 sliders positioned on the rectangular-coordinate arrangement of the Function Generator provide a graphic display of the output voltage versus time from the start of the program. A row of indicator lights located below each Function Generator indicates the horizontal position on the program at any time during operation. The sweep across the contacts is made by use of a Vernistat Interpolating Potentiometer.

The Vernistat

The Vernistat Interpolating Potentiometer (Fig. 5) can be described as a continuous single-turn potentiometer whose terminals are switched between a series of contacts. These contacts usually are connected to taps on either a tapped autotransformer (for a-c applications), or a tapped resistor (for d-c applications), or to any tapped impedance, as desired.

The principle is shown in Fig. 5. The single-turn precision potentiometer is shown with its output wiper. It is mounted on an eccentric which moves the pot terminals onto a series of contacts, shown on the outer circle. These contacts are connected to the desired external voltages.

In Fig. 5 (left), the wiper has swept from tap 1 to tap 2 and is about to sweep between contacts 2 and 3. Tap 1 is now out of operation, and the eccentric is about to move contact 1 so as to make contact with tap 4, as shown in the middle illustration. Note that one third of a revolution of the precision potentiometer is required for the wiper to sweep from tap 2 to tap 3.

When the wiper reaches tap 3, it begins its sweep from tap 3 to tap 4, at which time contact 2 is moved by the eccentric to tap 5. Thus the precision potentiometer sweeps all the way up the tapped voltages, continuously, as its terminals are stepped up the taps on the commutator.

Applications

Fig. 1 shows a system using the Marquardt Automatic Programmer. It is a variable-rate, automatically-controlled, material-test machine capable of si-

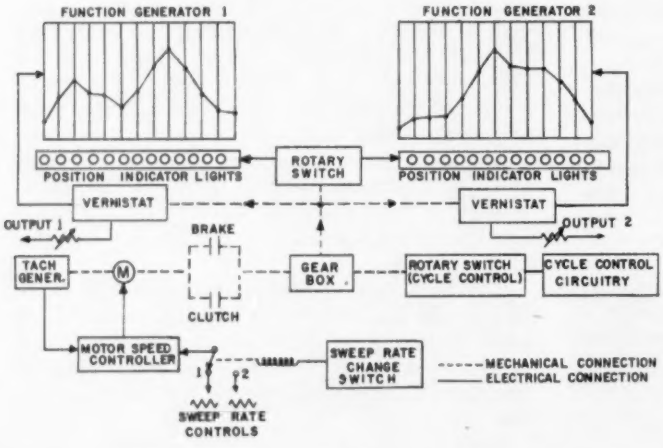


FIG. 3. BLOCK DIAGRAM of Marquardt dual-channel automatic programmer.

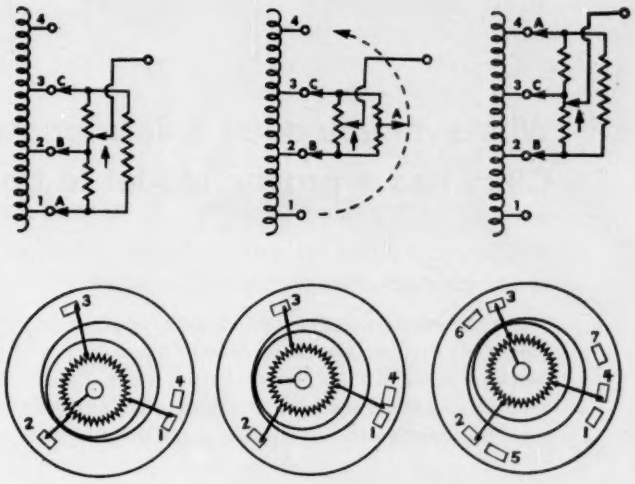


FIG. 5. VERNISTAT principle. As the outer wiper on the potentiometer sweeps between two taps (connected to external impedance), the eccentric steps the third contact to the next higher tap.

multaneous but independent control of specimen loading and temperature. The loading control system employs a hydraulic ram whose load is controlled by a servo valve, while the temperature is obtained by resistance heating (Fig. 6)—that is, the specimen itself carries the current and is therefore heated by I^2R. The loading on the specimen can be either stress-controlled (psi) or strain-controlled (inches of extension per inch of gage length). Both control systems are designed to accept any type of variable control signal within the frequency-response limitations of the equipment.

The use of the dual-channel programmer permits the operator to set up realistic simulated conditions of the environment to which the material will be subjected (usually simultaneous stresses and elevated temperatures, each with its own time function).

The programmer can stop automatically at the end of the programmable portion of the last selected level, and maintain the temperature and load (or strain) at this level for an indefinite period (provided the specimen does not fail).

A useful feature of the programmer in this application is the extreme ease in which the program can be revised even during the run if necessary. Because of the rapid loading and heating available, initial programs under manual control can result in premature specimen failure simply because the operator does not have sufficient specimen data under such testing conditions. Therefore, by modifying the program slightly, in seconds, the operator can make useful experiments by empirical means on specimens about which no previous data (under such test conditions) has been available.

Another application of the programmer has been in pressure control of a blowdown wind tunnel.

At the Air Force-Marquardt Jet Laboratory the Automatic Programmer is being used to simultaneously and independently program inlet pressure and temperature of a ramjet engine in a blowdown wind tunnel. A block diagram of the pressure control system is shown in Fig. 7.

The Programmer is ideally suited to process control, especially where the program is changed often or where trial and error is required.

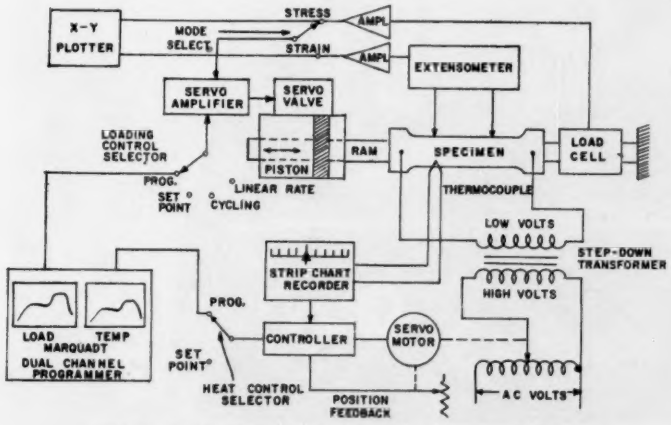


FIG. 6. BLOCK DIAGRAM of the Marquardt TM-1 Material Test Machine.

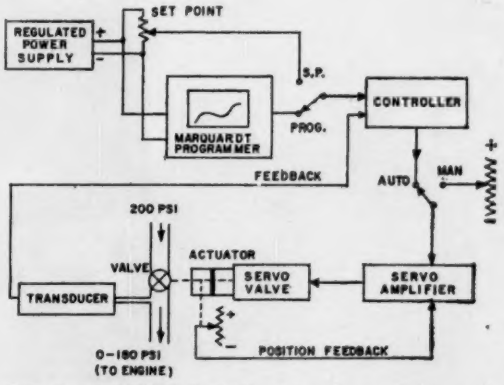


FIG. 7. PROGRAMMING a blowdown wind tunnel.

Whatever you need a data printer for, Clary has a proven model to do the job

At Clary you'll find the world's largest selection of solenoid actuated digital data printers.

These include Parallel Entry Printers, Printing Timers, Time-Data Printers, and Serial Entry Printers. All are reliable, proven printers... printers whose simple circuitry, low cost, small size, desk top mounting, and modern design have made them the most "asked for" printers in the world.

Clary Printers are now being used in the following applications:

Automatic Checkout Systems
Recording Scale Systems
Digital Voltmeter Readout
Logging of Time Signals from Digital Clocks
Shaft Position Readout
Instrumentation Data Recording
Logging of Time and Origin of Alarm Signals
Automatic Engineering Data Recording
By-Product Accumulation of Office Machine Operations
Process Control Data Recording

Clary

ELECTRONICS DIVISION
SAN GABRIEL, CALIFORNIA
Computing Devices of Canada, Ltd., Ottawa

Manufacturer of output printers, computers, electronic data-handling equipment, aircraft and missile components.

CIRCLE 61 ON READER-SERVICE CARD

PART 2: MEASUREMENT OF ACCELEROMETER OUTPUT

Accelerometer Calibration

Part 1 discussed the techniques for measuring the applied acceleration. Techniques for measuring the output of an accelerometer include measuring the ratio of output to input by division and comparison, and involve consideration of waveform. Practical circuits are given.

LAWRENCE MOSKOWITZ
Schaevitz Engineering

MEASURING THE RATIO of output to input is a convenient and accurate method of measuring the response of an accelerometer; calibration errors due to variations in applied voltage are cancelled out. In Fig. 1 the precision divider (potentiometer) is supplied from the same source as the accelerometer. The switch alternately connects the accelerometer output and the divider output to the meter. As the meter is used for comparison purposes only, its accuracy does not affect the accuracy of measurement. The potentiometer (divider) output is varied until the meter reading remains constant as the switch is alternated between the two circuits.

A chopper can be substituted for the switch and output observed on a scope. If chopper frequency is some multiple of the sweep rate the pattern will be as shown in Fig. 2 when the outputs are not equal. The operator adjusts the divider until the pattern is all at one level. An extremely sensitive indication of equality can be achieved by increasing the scope gain to a maximum and bringing the top (or bottom) of the pattern into view by means of the vertical centering control.

The meter output can be specified as total rms, fundamental rms, peak, etc. This establishes the type of indicating meter needed. A meter that responds to the average of a nonsinusoidal waveshape (such as rectifier-type meters) cannot be used to compare the rms values of two voltages with different harmonic content. Note that a scope is useful only for comparing peak values. Errors can results from lack of consideration of the waveform.

Accuracy

Precision voltage dividers (potentiometers) are available with accuracies up to 0.0025%; some inexpensive types have accuracies to 0.05%. These accuracies are expressed as the maximum error in output

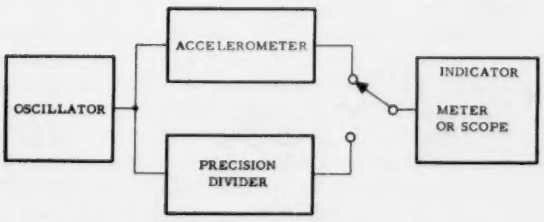


FIG. 1. USE OF a precision voltage divider as a comparison device.

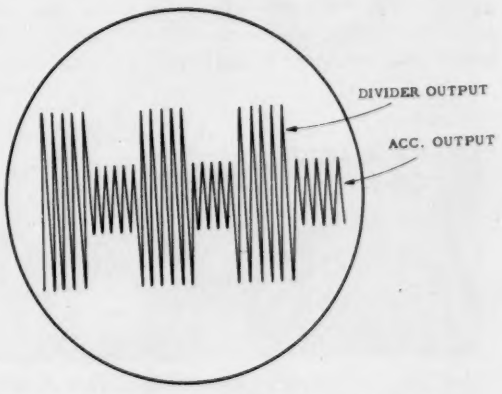


FIG. 2. SCOPE pattern when chopper is used.

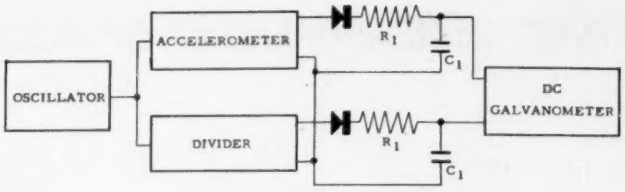


FIG. 3. AC SIGNALS from accelerometer and divider are first converted to dc, and then compared.

voltage, in terms of percent of the input voltage. Thus the error is larger for severe attenuation. The attainable accuracy is closely equal to the rated accuracy divided by the attenuation ratio. For example, a divider rated at 0.0025% achieves only 0.025% accuracy for ratios near 0.1.

The relationship between the impedance of the divider and the impedance of the indicator into which it works also has an important bearing on the overall attainable accuracy. If the ratio of load impedance to divider impedance is R, and the actual divider reading is D, the % error is given by the expression:

$$\% \text{ Error} = 100D(1 - D)/R$$

For example, if the meter impedance is 50 times the divider impedance, and the ratio is 0.5000, the error will be 0.5%; for ratios 0.2500 and 0.7500 the error will be 0.38%. The error tapers to zero at unity and zero ratios. A good practical impedance ratio is 1000, corresponding to a 10-megohm load on a 10 K divider. The worst error in this case would be 0.25% at a ratio of 0.5000.

Measurement of Static Linear Output from an Accelerometer on the Rotary Accelerator

A new and useful method requires converting the a-c accelerometer output to dc, and comparing the resultant dc with an accurate d-c reference. This method eliminates errors caused by accelerator slip ring intercoupling and capacitive loading of shielded leads. The d-c reference is derived from a precision voltage divider powered from the same a-c source as the accelerometer.

In Fig. 3 identical rectifier circuits convert both the accelerometer output and the divider output to dc. Matched rectifiers charge up low-leak capacitors (C_1) through high resistances (R_1). When the capacitors are fully charged, the a-c sources are essentially unloaded and consequently unaffected by the capacitance of the interconnecting wires (such as brush rigging, slip rings and associated shielded leads).

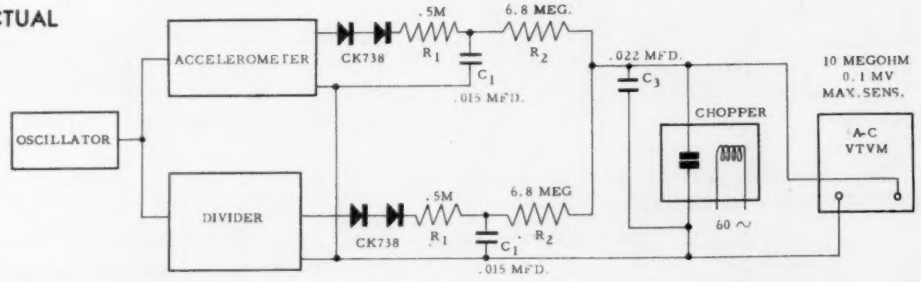
When the rectifiers are connected to develop the same polarity, the combined output can be connected to the balanced input of a high-sensitivity, high-impedance d-c galvanometer. A circuit using more readily available instruments is shown in Fig. 4. This is accurate in measuring output voltages from 2 to 50 volts. Each capacitor C_1 is loaded with 6.8 megohms, which leaves the capacitors essentially unloaded. The common junction of the 6.8-megohm resistors is returned to the low-potential end of the capacitors through a 60-cycle chopper. A sensitive a-c vacuum-tube voltmeter (0-1 millivolt full-scale sensitivity) is connected across the chopper, and capacitor C_3 (0.022 μfd) is connected in parallel with the chopper. This capacitor charges up to the *difference* in potential between the two halves of the circuit and is discharged each time the chopper closes. These successive voltage rises appear to the voltmeter as an a-c voltage. The capacitor also diminishes the amplitude of any residual higher-frequency carrier voltage. As in the a-c comparison method, high harmonic-content can effect accuracy because the capacitors C_1 charge up to peak voltage.

When the system is properly shielded and grounded, the null of the system will be easily visible on the 1-millivolt scale of the voltmeter. The sensitivity is sufficient to indicate the fourth digit of the precision divider.

Measurement of Periodic Linear Acceleration

In measuring the response of an accelerometer to sinusoidal acceleration, it is desirable that the accelerometer output consist of a sine wave of voltage whose phase and amplitude is proportional to the accelerometer response. If there were also available a voltage whose phase represented the phase of the applied acceleration, these two voltages combined on

FIG. 4. ACTUAL circuit.



an oscilloscope would appear as an ellipse. The phase angle between the two could be measured by the method shown on Fig. 5.

Unfortunately, the output of a carrier-type of accelerometer appears as a modulation of the carrier; it cannot be separated from the carrier with simple circuitry without affecting the phase and amplitude information contained in the modulated carrier. The modulated carrier, however, can be combined with the sinusoidal voltage representing the applied acceleration, and the pattern will appear as shown in Fig. 6. This pattern represents an accelerometer operating about its null. Each ellipse is the resultant of the sinusoidal envelope of the negative and positive carrier excursions, combined with the sinusoidal applied acceleration voltage. If the accelerometer were operating displaced from its null (such as a horizontal accelerometer being vibrated vertically) the pattern would appear as shown in Fig. 7. As the phase information contained in the modulated carrier is not distorted by any added circuitry, it is accurately represented by the ellipse orientation.

The criterion for natural frequency, by definition, is the existence of a 90° phase lag between the accelerometer response and the applied acceleration. This condition would be represented on the scope by the ellipses opening up to circles.

It is difficult to observe the precise frequency when the ellipse changes from one of small eccentricity to one of zero eccentricity (full circle). It would be desirable if the criterion for natural frequency were 0° or 180° phase lag because this is represented by the ellipse contracting to a single line. This can be accomplished if an additional lag or lead of 90°, effective at all frequencies, can be introduced. As the vibrator velocity is displaced 90° in phase from its displacement, a voltage proportional to vibrator velocity would be ideal—this is available by using the output of the velocity pickup attached to the table.

The ratio of scope intercepts is considered to be the cosine rather than the sine of the phase lag, and the angle corresponding to the cosine is then the actual phase lag.

The accelerometer response is measured by applying the accelerometer output to a precision voltage divider and thence to the scope horizontal amplifier (Fig. 8). For the lowest applied frequency the divider is set to some convenient ratio, such as 0.1, and the scope gain adjusted so that one of the ellipses is some convenient horizontal level in scope divisions. For any other applied frequency at constant amplitude, the divider ratio is adjusted to restore the horizontal amplitude to the original level. Relative response is calculated with respect to the lowest reference frequency by dividing the lowest frequency voltage-divider setting by the voltage-divider setting at any other frequency. This method and the method given in Part I (Measurement of Applied Acceleration) provide complete instrumentation for the examination of dynamic accelerometer characteristics.

Measurement of Periodic Angular Acceleration

This method for linear acceleration is applicable in its entirety to angular acceleration as applied by

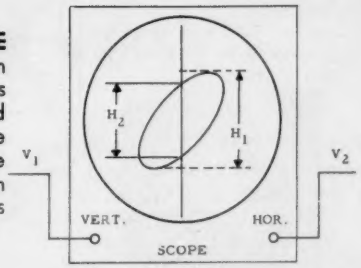


FIG. 5. PHASE ANGLE between two waveforms can be measured by pattern. Sine of the phase angle between V_2 and V_1 is H_2/H_1.

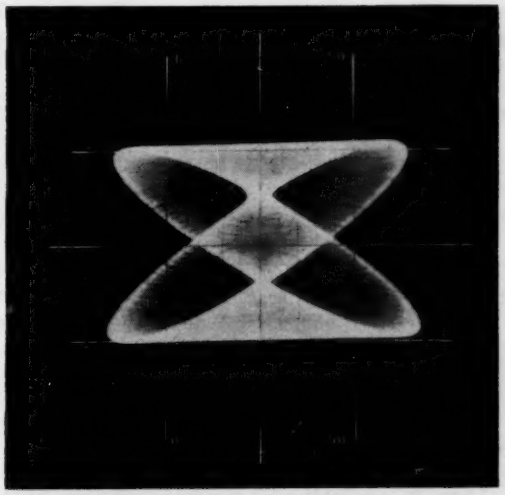


FIG. 6. PATTERN with modulated carrier, with accelerometer operating about its null.

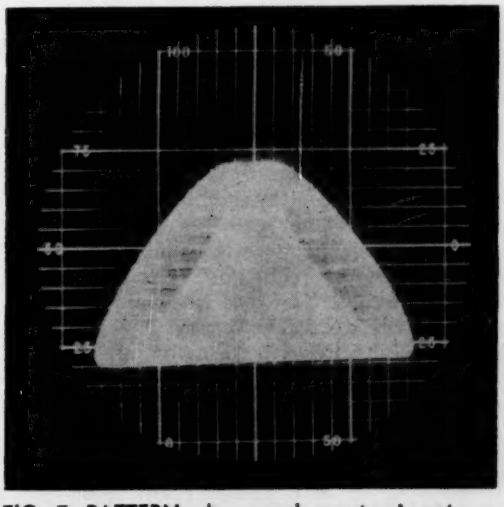


FIG. 7. PATTERN when accelerometer is not operating about its null.

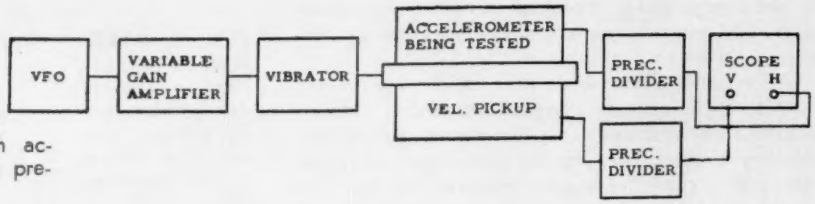


FIG. 8. TEST SETUP with accelerometer connected to a precision divider.

rocker arm attachment to the linear vibrator (Fig. 9).

In the calibration of angular accelerometers by the application of accurately known low-frequency periodic acceleration, a two-channel oscillograph can be used advantageously. As some friction in a pendulum is unavoidable, an acceleration corresponding to a specific angle of swing may occur only once as the angle of swing is attenuated in successive swings. This is no hindrance if the angle of swings and the accelerometer output are continuously recorded.

Many types of recorders available have flat frequency-response characteristics to at least 30 cycles. On the basis of calibrating at a frequency of one tenth the natural frequency, this would enable calibration to be made on angular accelerometers with natural frequencies up to 300 cps. Continuous angular measurements can be made by sensing the pendulum angle with the RVDT (a low-torque rotary version of an LVDT).

Fig. 9 illustrates a system for such measurements. Phasing networks shown are required if the recorder does not provide internal phasing circuits. Calibration is made by setting the pendulum swinging at an angle larger than required and allowing it to decay through the precalculated angle. The recording of the angle-measuring channel is examined to determine the point

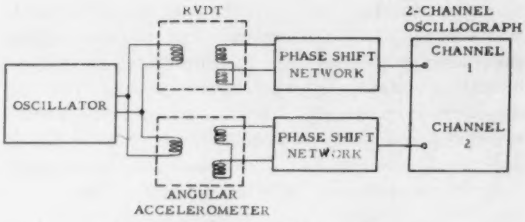


FIG. 9. TEST SETUP for calibrating an angular accelerometer on a pendulum, using an RVDT for comparison.

corresponding to the first appearance of the precalculated angle.

The accelerometer output at the corresponding point on the adjacent channel represents the accelerometer response. The simplest method of calibrating in actual volts would be to apply the output of an LVDT (of the same type used in the accelerometer) to the input of the recorder or phasing network. The LVDT core is moved to establish the same height of recorder trace. The LVDT output then can be measured in any convenient manner.

Addition to Our Timer Survey

Cramer Controls Corp. automatic reset interval timer Type 241 (see Fig.) provides push-button starting, automatic shut-off and instantaneous reset. Twelve time ranges available are from 6 seconds to 24 hours. Repeat accuracy (precision) is within ±0.25% of full scale on timers with ranges of 30 seconds or longer; ±0.5% of full scale on shorter than 30-second ranges.

Type 412 time-relay provides an accurate, adjustable time delay between the operation of a control circuit and the subsequent closing of one or two load circuits. The unit is equally applicable as a remotely controlled, automatic reset interval timer, opening an electrical circuit a selected interval after simultaneous energization of the control and load circuits.

Type 620 is a miniaturized elapsed-time indicator. Total registration is 9999.9 hours, required operating power is 115v ac at 60 or 400 cycles. Housing forms are available for front-panel and for back-panel mounting. Total weight is about 4

620 412 691

ounces. Elapsed time is recorded on the counter in hours and tenths of hours.

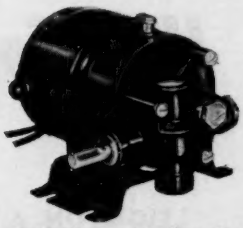
High-precision time totalizer Type 691 is an electrical stop clock capable of measuring elapsed time to 1/100 of a second. To initiate timing, circuit is closed by electromagnetic actuated clutch. On completion of timing, clutch circuit is opened. Accuracy of 50, 60 and 400 cps timers is within 0.01 second for each operation, at rated frequency. Some additional accuracy can be achieved through the use of a d-c clutch in combination with a synchronous drive.

You Can Find What You Need Quickly...

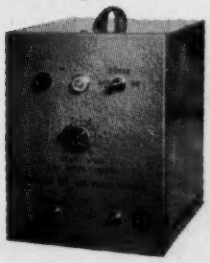
. . . thru our ready reference stock list file which is now being used daily by thousands of firms all across America. It classifies by groups and according to size the lines we handle, some of which you see illustrated to the right.

All items are listed specifically and full information is given, including: PRICES — Engineering Data — Dimensions — Technical Information — Electrical Specifications . . . and all of the many thousands of items listed are ready for IMMEDIATE DELIVERY in single or multiple unit lots.

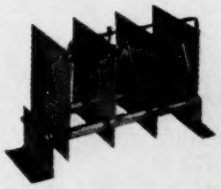
This catalog will save you many hours of time and considerable effort all thru the year . . . so if you do not as yet have your copy, send for it today . . . there is no obligation.



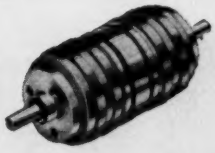
GEARED & NON-GEARED ELECTRIC MOTORS — AC, DC, SYNCHRONOUS — 1/2000 TO 25 HP — Authorized Distributor: **BODINE ELECTRIC**



HELLER THYRATRON & SOLID STATE CONTROLLERS & MIXERS.



SILICON & SELENIUM RECTIFIERS — TRANSFORMERS & CHOKES.



SIMPLATROL ELECTRIC CLUTCHES & BRAKES.

B & B MOTOR & CONTROL CORP. 206 LAFAYETTE ST. NEW YORK 13, N. Y. WOrth 6-5777

CIRCLE 83 ON READER-SERVICE CARD

CUT COSTLY INSTRUMENT MAINTENANCE

with

Clean Dry Oil-Free Compressed Air

An Adams aftercooler and cyclone separator installed in your instrument air supply cools the discharge air to within 2° of cooling water temperature. Over 90% of the moisture and virtually all of the oil are condensed. The exclusive Adams cyclone separator then removes the condensed liquid oil and water and other foreign material with uniform high efficiency — over the entire operating range. This air is entirely suitable for air motor and most control applications. When bone dry air is needed, the chemical drier load is then limited only to polishing action, since the bulk of the moisture will have been removed by lower cost condensation. Why not review the cost cutting advantages of an Adams aftercooler-separator combination? Ask today for your free copy of Bulletin 714, R. P. Adams Co., Inc., 265 East Park Drive, Buffalo 17, New York.

ADAMS *QUALITY COMES THROUGH*

CIRCLE 84 ON READER-SERVICE CARD

NEW! FROM PRINCO

A SMALL TRANSISTORIZED RELAY FOR BIG JOBS

Controls loads up to 1500 watts at 110 volts

This Supersensitive PRINCO T-681 relay offers many advantages in size and performance.

1. Small size, light weight—only 3" x 4" x 5", weighs 30 ounces.
2. Transistorized Circuitry—no tubes or batteries to replace.
3. High Temperature Operation—thermistor compensation permits operation in ambients to 120°F.
4. Provides Activating Current of 15 Microamperes, controls loads to 1500 watts.
5. Higher Input Sensitivity—operates through as much as 250,000 ohms across input terminals.
6. Switch lock gives positive control of normally open or normally closed loads.
7. Shock and vibration resistant, mounts in any position.

The T-681 is designed for rugged, long lasting operation with thermostats, thermoregulators and other applications where a highly sensitive, extremely dependable relay is required for microampere operation.

For further information or bulletin,
WRITE, WIRE OR PHONE

Precision Thermometer and Instrument Co.
1434 Brandywine St., Phila. 30, Pa. Phone LOcust 3-6671

PRINCO

CIRCLE 85 ON READER-SERVICE CARD

High-Speed Monitor Scans

LEIGHTON A. MEEKS
Monitor Systems, Inc.
A Subsidiary of Epsco, Inc.

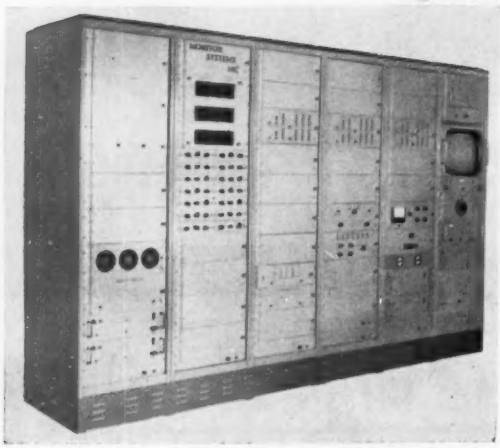


FIG. 1. HIGH-SPEED automatic monitor (HAM) system.

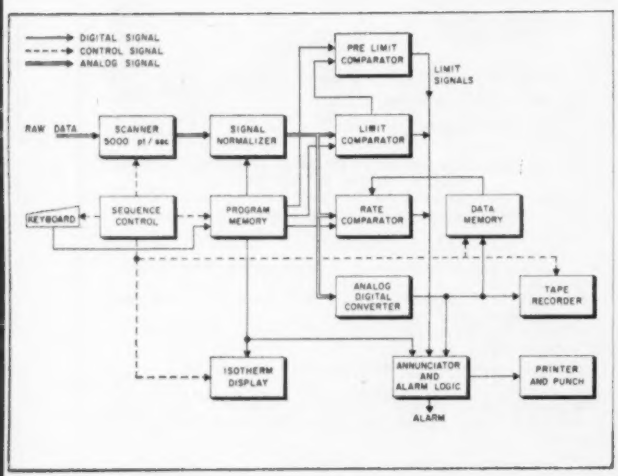


FIG. 2. BLOCK diagram of system.

NUCLEAR POWER REACTION is a critical process which would "run away" without close control. Reliability of operation depends not only on the performance of the control system but also on a supervisory data-reduction system having shut-down capabilities and operating completely independently (in parallel with process). The shut-down system must be purely mechanical, acting by gravity or spring force upon a signal received from the supervisory system.

A digital control system offers advantages in its possibility to recover low-level signals in heavy noise. This multiplexed monitoring system uses data-reduction techniques. It processes raw data received in analog form for the purpose of generating alarm signals and shutting down the nuclear reaction by full insertion of the control rods.

The quarter-million-dollar High-Speed Automatic Monitor (HAM) System shown in Fig. 1 has been developed for the GE Hanford Atomic Products Operation (HAPO), Richland, Washington. (Total value of HAPO at end of 1959 was estimated at $1,173,800,000.) A major design effort was devoted to producing a system with the greatest possible reliability. False alarms are prevented by self-checking every 0.8 second. Furthermore, logic of the checking channels has been extended to provide automatic localization of failures. Thus the HAM System performs its own trouble-shooting.

The complete cycle of operation is done at a rate of 5,000 inputs scanned per second or, when operating on the 3,600 resistance-bulb temperature sensors at Hanford, the complete cycle will be 0.8 second. On each cycle it:

1. **Measures for temperature (3600 points) and compares to a preset value.**
2. **Determines rate of rise, if any, and compares to preset value.**
3. **Converts analog voltage to digital form for binary readout, and presents CRT display.**
4. **Monitors irrational highs and lows.**
5. **Self checks all its own circuitry.**

5000 Inputs / Second

An ultra-reliable 5000-point/second monitor meets specs calling for 1250 hours operation with not more than a single high-temperature false alarm (or more than two false alarms of other types). This unprecedented reliability permits operation of a nuclear reactor within 4C° of "scram."

Reliability of the system has been upgraded through "worst-case design." Circuitry is designed to provide reliable operation despite combined changes in transistor and diode characteristics, and transistor, capacitor, and power-supply drifts. All components, such as semiconductor diodes, transistors, carbon resistors, deposited-carbon or metal-film resistors, capacitors, precision wire-wound resistors, and magnetic devices, are considerably derated.

Resistance temperature detectors (RTD) are the primary sensing elements installed at various points in the reactor. A potential ranging from 0 to 0.8V across each RTD varies with the temperature.

Six separate comparisons are made simultaneously for each input channel, through six operational amplifiers, for the following conditions—high limit, rate-of-change (limited to ten channels), irrational high, irrational low, approach-to-trip, visual display.

There are three types of Numerical Alarm Display Annunciators—Temperature, Irrational, and Approach-to-Trip. The Rate-of-Change Alarm is not displayed as a temperature value; these alarms are accumulated in a Rate Alarm Accumulator, up to a presetable number (N), which can have a value from 1 to 15. When the total number of rate alarms accumulated exceeds the preset number (N), then the Alarm Terminal Board is triggered.

The method of computing rate-of-change was customer specified. It was a requirement, in effect, that the system measure the difference of the samples to ± 0.02% of full scale (referred to a 1-volt input), and to maintain this precision for 1250 continuous hours. To do this, the analog-to-digital converter was improved to do double duty. It not only converts to 4-decimal digits, but performs the rate computation as well. Only 90 microseconds can be allowed for the entire combined operation.

A monitor scope provides a visual plot of isotherms. A bright spot indicates that a particular channel exceeds the setting of the CRT preset. Its position, with reference to the graticule overlay, identifies the channel.

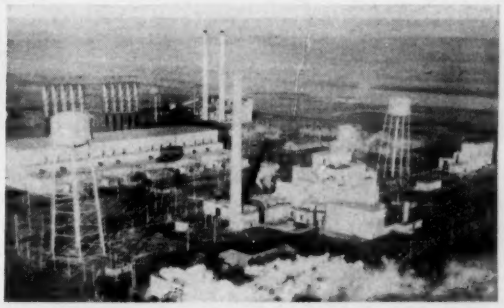


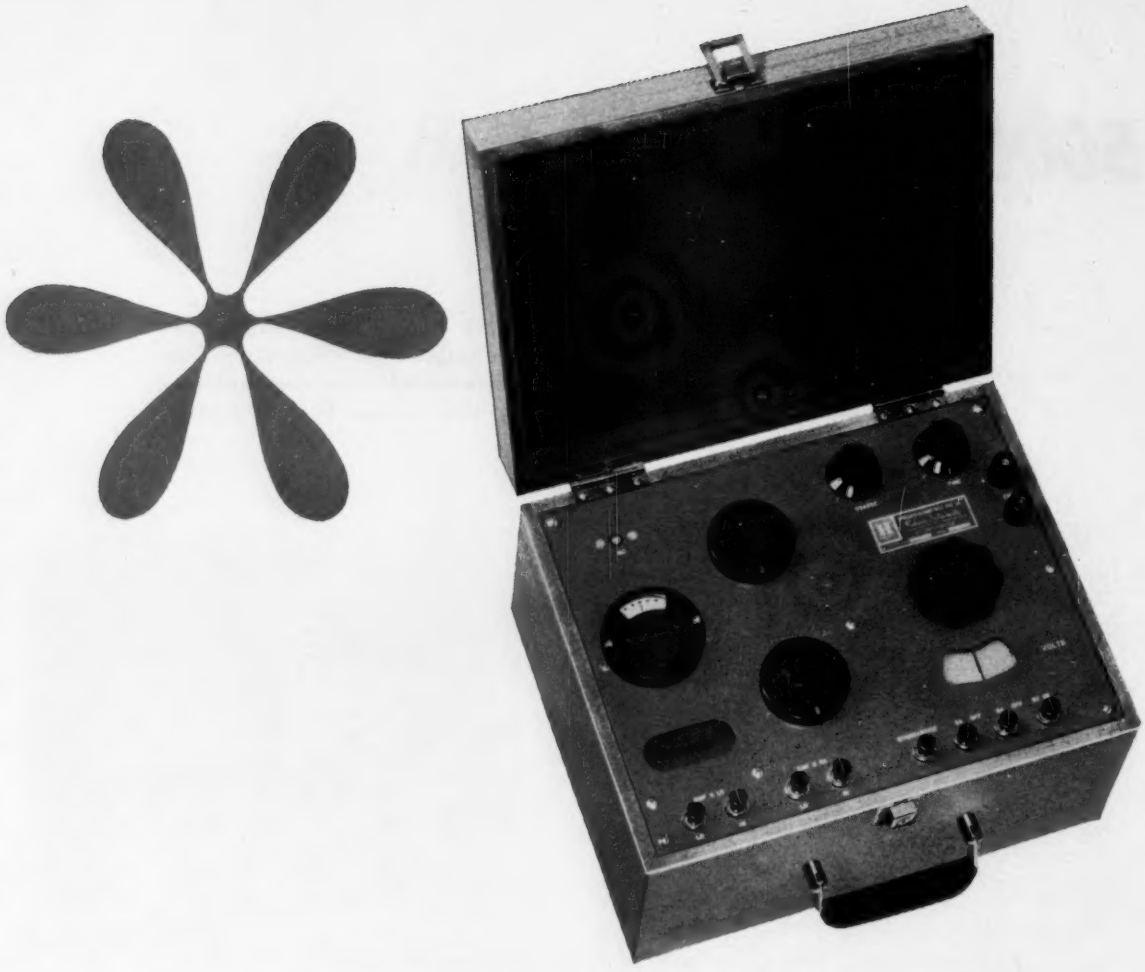
FIG. 3. THE GE Hanford reactor, Richland, Washington.

Acceptance Requirements

Reliability of the system was established by a test of unprecedented severity. Continuous operation for 1,250 hours was required, with not more than a single high-temperature false alarm or more than two false alarms of other types. In other words, only one or two false alarms (depending on the type) were permitted in a total of 22,500,000,000 readings.

This performance is not fully appreciated until one notes that full-scale change is only 0.8 volt, and that the sum of drift and noise must not exceed 200 microvolts peak referred to the input. Settling time (transient response) to 0.01% must not exceed 100 microseconds. Long-term system accuracy required is 0.5%. The system has met these unprecedented requirements in its rigorous 1250-hour acceptance test.

The HAM System, because of its high reliability, is expected to contribute significantly toward the goal of ultra-reliable operation of large nuclear power plants. Self-healing features ultimately may be added as a natural extension of the self-check features presently incorporated. Self-healing would provide for split-second repair of marginal or failed modules on an automatic basis.



HOW SHOULD YOU EVALUATE POTENTIOMETER ACCURACY?

Accuracy in an instrument is more than a matter of how closely measured values correspond to true values. Some potentiometers, for example, may be capable of sky-high accuracy—but only under ideal laboratory conditions. Other potentiometers may deliver consistent high accuracy . . . higher than you actually need . . . with the penalty of excessive cost.

A realistic evaluation of potentiometer accuracy, then, involves consideration of stability and reproducibility as well as stated limits of error. By these criteria, Rubicon potentiometers, galvanometers and bridges should be YOUR choice.

By any measure, the new Rubicon 2746 *portable* potentiometer is an outstanding instrument. Ranges 0—1.601 and 0—0.1601 volts. Limits of error are constant, realistic, usable: high range—30 microvolts or 0.03% of reading, whichever is larger. Low range—3 microvolts or 0.045% of reading, whichever is larger. Depend on it for *consistent* accuracy. **Write for Specification Sheet RS-2746, for details.**

Rubicon accuracy stems from a long tradition of engineering excellence and a pride of craftsmanship that is not easily found these days. You can sense this about Rubicon instruments, even before you put them to work. And today the Rubicon tradition of the finest in measuring instruments is being perpetuated by both small refinements and major advances in design . . . to make the best even better. The complete line of Rubicon instruments is available through any of the Honeywell branch offices across the nation.

MINNEAPOLIS-HONEYWELL, Rubicon Instruments, Ridge Ave. at 35th Street, Philadelphia 32, Pa.

Honeywell

First in Control

SINCE 1885

HONEYWELL INTERNATIONAL
Sales and Service offices in all principal cities of the world.

CIRCLE 86 ON READER-SERVICE CARD

PRECISION MEASUREMENTS ASSOCIATION

Pres. .....WILLIAM K. GEIST, W. K. Geist Co., Los Angeles, Calif.
V. Pres. .....HOWARD KEMP, Borg-Warner Controls, Santa Ana, Calif.
Secty. .....FRANK THOMA, General Radio, Los Angeles, Calif.
Treas. .....A. K. EDGERTON, Western Instruments, Burbank, Calif.

Reference and Working Electrical Standards

THE FUNCTION of the *reference standards* of a laboratory is to maintain locally a continuity of value in the units of measurement that they embody. Successive comparisons with the higher-echelon standards of the NBS by means of interlaboratory standards shipped back and forth will give an indication of any slow drift of the reference standard. When this cumulative drift exceeds the confidence interval of the values derived by the comparisons with the interlaboratory standards, the value assigned to the reference standard is corrected accordingly. The reference standards are used primarily to calibrate periodically the *working standards* of a lower echelon, such as indicating instruments. Also, on occasion they may be used as working standards themselves.

It is evident that both reference standards and working standards should be as permanent and reliable in construction as possible. Definiteness and repeatability are of major importance, whereas sensitivity, low losses, and freedom from extraneous influences are relatively much less important. Closeness of adjustment to nominal value is of decidedly minor importance. An undetected change in a reference standard may easily initiate a chain of error that will propagate throughout the plant and cause losses in time and material exceeding manyfold the original cost of the standard. Hence, these reference standards should be purchased only on very strict specifications, and from manufacturers of high reputation and of long experience in producing shop instruments and apparatus of demonstrated permanence.

Standard Cells

A large and important laboratory, which is expected to need a standard of voltage with an accuracy of 0.002 percent and to certify the emf of unsaturated standard cells used in its plant or by its subcontractors, normally maintains as a reference standard a group of 5 or 6 cadmium standard cells of the saturated type. These cells are relatively permanent but have a temperature coefficient of about 0.005 percent per degree Celsius (centigrade) at room temperature. They must therefore be kept in a bath thermostatted to ±0.01 deg centrigrade. A highly refined, water-white, acid-free mineral oil, having a viscosity of about 0.25 poise at 25°C and a flash point of 170° C, has been found suitable for baths for standard cells and for resistors. Such a group of saturated cells should preferably be checked initially at NBS and its value reassigned annually for the first 3 years and biennially thereafter, by using a second group of 2 or 3 saturated cells as an interlaboratory standard. The individual cells of the reference group can be intercompared monthly. The reference group is used to check the laboratory's working-standard cells of the unsaturated type and, on occasion, shop-standard cells also.

For laboratories requiring an accuracy of not over 0.01 percent in their standard of voltage, the reference standard often consists of a group of three cadmium standard cells of the unsaturated type. The individual cells are intercompared weekly by connecting them by pairs in series opposition and measuring the differential emf. These cells have a very small temperature coefficient and can be shipped safely by parcel post (if carefully packed). However, they are less constant than saturated cells and their emf usually decreases at a rate ranging from 40 to 120 microvolts per year. Therefore, their values should be reappraised at least annually on the basis of a periodic check from a higher echelon. A second group of 2 or 3 unsaturated cells can be used as an interlaboratory standard for such checks. When the emf of an unsaturated standard cell has fallen below 1.0183 volts, it is approaching the end of its useful life and can no longer be used as a reference or an interlaboratory standard. Following a moderate change in temperature, many cells tend to show a very considerable change in emf, which may persist for several days. This thermal "hysteresis" must be guarded against by allowing cells to stand for some time after shipment before taking readings. Temperature troubles with unsaturated standard cells can be minimized by keeping them

Abstracted from NBS Circular 578, *Suggested Practices for Electrical Standardizing Laboratories*, by Francis B. Silsbee (Aug. 30, 1956). Available from Sup't of Documents, US Government Printing Office, Washington 25, D. C., 15 cents.

in a thermally lagged copper-lined box. This reduces temperature fluctuations and differences in temperature between the two electrodes. It is important that the leads be brought out through very high grade insulation to an external terminal board.

Resistors

If the laboratory possesses at least two standard resistors of each decimal value covering the range over which it expects to make accurate measurements, one of these can be submitted to NBS every 2 years as an interlaboratory standard, while the other resistor of each pair remains undisturbed as a reference standard in its laboratory.

Inductors

Many laboratories find it useful to possess two fixed standard inductors of each decimal value over the range it expects to cover with accurate measurements. In recent years the quality of standard inductors has been greatly improved, but the NBS does not yet have sufficient data on the stability of the newer types to make a definite estimate of their expected stability. It is suggested therefore that one inductance standard of each denomination be submitted annually to the NBS, until a sufficient history is obtained to predict its performance.

Capacitors

Each laboratory should possess two capacitance standards of each decimal value and type needed to cover the range of concern. After its initial check at NBS, one standard of each value can be kept as a reference standard while the other is submitted to NBS at regular intervals as an interlaboratory standard. This interval should initially be 1 year for any one pair of standards. After the first 3 or 4 calibrations, an examination of the record will indicate the appropriate future frequency of calibration, taking into account the actual accuracy demands made on particular standards. On variable air capacitors the eccentricity correction ordinarily will be determined only during the initial calibration; thereafter, calibration at a few cardinal points is usually sufficient.

Volt Boxes

Each laboratory should have one volt box with a plurality of ratios, which can serve as a reference standard. This can be checked initially at NBS. Unless the laboratory is rather large, the same volt box may be rechecked at NBS at intervals of 2 years, and thus serve as an interlaboratory standard also.

Time Standards

Although time is not an electrical quantity, many electrical laboratories require reference standards of time or of frequency. A high-grade seconds pendulum clock with photoelectric pickup or a standard crystal-controlled oscillator may form the reference standard. Either can be calibrated by reference to the standard-frequency radio signals emitted by NBS stations WWV or WWVH. By the use of a multivibrator in combination with the reference-standard oscillator, the frequency of working-standard oscillators can be calibrated over a wide range. Such an oscillator can be used to control a standard frequency circuit to which, in turn, synchronous timers can be connected to serve as working standards for measuring time intervals. The use of the frequency of local electric-power circuits as a time standard, while very convenient, may be subject to errors approaching 1 percent for short periods of time, even though the average frequency over a longer time as shown by a clock is very high. These short-time fluctuations in frequency are materially less if the supply is tied in synchronism with a large power system.

WORKING STANDARDS

The working standards constitute the principal tools of the standardizing laboratory. They are calibrated at intervals by comparison with the reference standards, and used in the daily work of checking shop instruments. The number needed of any one kind and range will depend upon the volume of testing service demanded in that range. If the volume is very small, and also in special cases where extreme accuracy is needed, a reference standard can be used as a working standard also.

Most laboratories will need a number of unsaturated cadmium standard cells to serve as working standards and relieve their reference cells of excessive use and of the hazard of accidental abuse. Such working-standard cells should be checked against a reference standard at intervals of 1 or 2 weeks.

METROLOGY LECTURE SERIES

P.M.A. is sponsoring a "Metrology Lecture Series" of twelve, weekly, 2-hour sessions. Cost is $24 for non-P.M.A. members, $12 for P.M.A. members:

1—March 16. Organization of a Standards Program. Panel
2—March 23. High Accuracy DC Measurements. George Vincent, Nortronics
3—April 6. Low Frequency AC Measurements. Clarence Catherman, Hughes Aircraft
4—April 20. Microwave Measurements. Ted Mukaihata, Hughes Aircraft
5—April 27. Frequency Measurements. Sy Ramey, Hewlett-Packard
6—May 4. RF Measurements
7—May 11. Impedance Measurements
8—May 18. Pressure Measurements
9—May 25. Mechanical Measurements. John Harrington, MetroLonics
10—June 1. Flow Measurements. Bernard Artz, Fischer & Porter.
11—June 8. Temperature Measurements. Gene Nutter, Atomics International.
12—June 15. Mass Measurements. Miss E. Clinton, Atomics International.

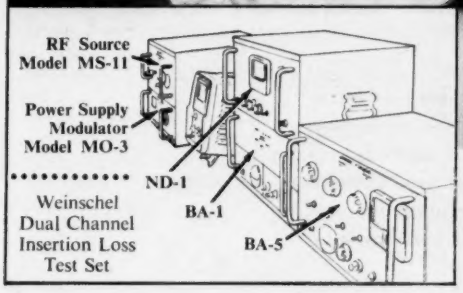
Meeting Notice

April 5, 1961, Michael's Restaurant, 6309 E. Washington Blvd., North of Santa Ana Freeway, Los Angeles.

Subject: Precise Impedance Measurement in VHF and UHF Range. Robert Soderman, General Radio Co.

ONLY THE DUAL CHANNEL TEST SET MEASURES SMALL RF ATTENUATION DIRECTLY

(PRECISE TO 0.01 DB AT 10 DB; TO 0.002 DB AT 2 DB)



Because measurements can be made quickly and easily, this equipment is used in Standards Labs and Quality Control as well as in Production and Research.

This is the only direct reading equipment available for the precise measurement of small losses. It measures the "zero loss" of switches, cable assemblies, and waveguides. "Forward loss" of isolators, and loss and "wow" of rotary joints can be quickly determined. For losses below 2 db. the resolution is about 0.002 db.

The calibration of 50 DB X-band waveguide variable attenuators is one of the many applications of the more than 400 Weinschel Dual Channel Insertion Loss Test Sets now in use in laboratories, quality control departments and production lines all over the country. Test logs of individual customers show thousands of precise measurements with negligible down-time and maintenance.

SPECIFICATIONS:

Precision: 0.01 DB per 10 DB despite changes of 0.1 DB in level of RF source.

System Accuracy: 0.02 DB per 10 DB.

Attenuation Range: 20 DB direct.
40 DB with 20 milliwatt input and partial RF substitution.

Frequency Range: 20 MCS to 90,000 MCS.

The Instruments:
Model BA-1 Bolometer Preamplifier.
Model ND-1 Differential Null Detector.
Model BA-5 Attenuation Calibrator.

For theory, method, required instruments and recommended accessories, write for Weinschel Engineering Application Note No. 4.

WEINSCHEL ENGINEERING®

WE CO

KENSINGTON, MARYLAND Phone: LOckwood 4-0121 TWX Kensington, Maryland 446

CIRCLE 87 ON READER-SERVICE CARD

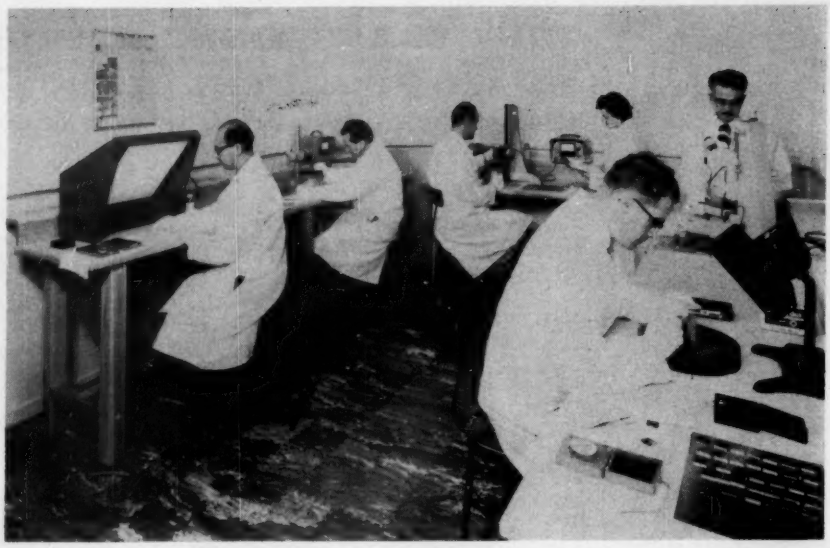


FIG. 1. COMPARATOR ROOM. Flatness calibration is performed with helium and mercury lights, optical flats, Davidson plano interferometer, and Zeiss interference microscope. Size measurements are made with Indi Ac Comparators, Para Ac Comparators, and Micro Ac Comparators.

Independent Standards Laboratory

An independent standardizing laboratory—MetroLonics, Inc.—has begun operation with an investment of about two-hundred-thousand dollars. It provides another important link between the National Bureau of Standards and all manufacturers and researchers who must use precision instruments.

UNDER recently revised regulations of the Department of Defense, all prime contractors and their sub-contractors must demonstrate that their precision measuring instruments have been compared to and referenced to the primary standards in the National Bureau of Standards. This laboratory provides a link between the NBS and all users of precision instruments.

Facilities

An environmentally controlled laboratory maintains a constant temperature of 68°F ±0.2°F, and a constant 40% humidity, twenty-four hours a day.

The equipment is listed in Table 1, with calibration accuracies noted.

A German-made Zeiss Koester Interferometer measures the lengths of gage blocks to one-tenth of one-millionth of an inch by comparing interference bands of Krypton light in four colors, or Helium light in six colors. Another German-made instrument is the Zeiss Universal Measuring Machine which measures size and shape in two axes of measurement to fifty-millionths of an inch, and around two planes of rotation to one minute of arc—without the part being removed from the instrument. Helical Path Analyzer for Screw Thread Gage plots deviations to 1×10^{-5} inch. Talyrond plots roundness to 3×10^{-6} inch.

Further expansion is scheduled in hydraulics, electronics, mass and pressure, microwave, optics, and infrared standards.

The NBS and MetroLonics both have the capability of measuring and reporting to the nearest 0.1×10^{-6} inch, but both will only certify to the grade requirements of Federal Specification GGG-G-15. This simply means that both organizations are capable of measuring and reporting closer tolerances than are required for today's certification.

Equipment Suppliers

Talyrond	Engis Equipment Co.
Zeiss Optical Machine	Scherr-Tumico Co.
Koester Interferometer	Scherr-Tumico Co.
Supermicrometer	Pratt & Whitney
Internal Comparator	Pratt & Whitney
Micro Ac Comparator	Cleveland Instrument Co.
Indi Ac Comparator	Cleveland Instrument Co.
Auto Collimators	Davidson Optronics
Plano Interferometers	Davidson Optronics
Monochromatic Sources	Van Keuren
Profilometer	Micrometrical Mfg. Co.

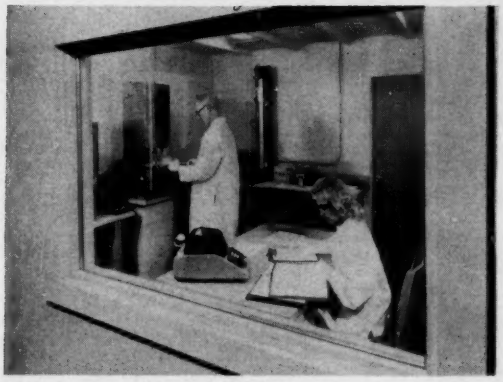


FIG. 2. INTERFEROMETER room contains Zeiss Koester interferometer and automated electronic interferometer.

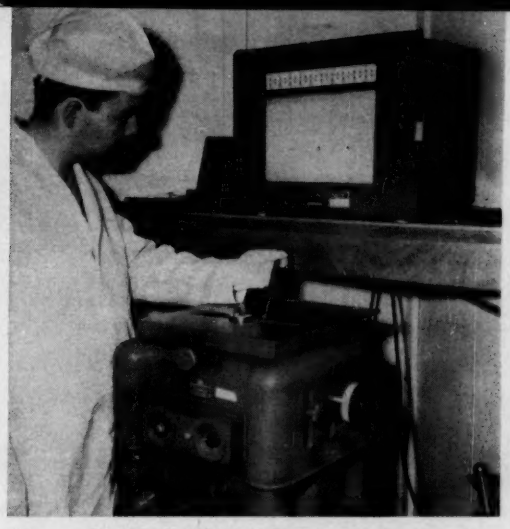


FIG. 3. PRATT & WHITNEY Internal Comparator.

TABLE 1—ACCURACY OF LINEAR STANDARDIZING LABORATORY INSTRUMENTS USED TO CALIBRATE REFERENCE STANDARDS

	Scale Reading per Division	Instrument Calibrated to:	Ref. Stds Used Calibrated by:	Instrument Calibrated* by:
Link Fringe Count Micrometers	0.000,000,116"	Light Waves	NBS	
Zeiss Interference Microscope	0.000,000,01"	Light Waves	NBS	
Koesters Interferometers	0.000,000,1"	Light Waves	NBS	
Taleyrond	0.000,010"	0.000,001"	NBS	
P&W Helical Path Analyzer	0.000,010"	0.000,001"	NBS	
Master and Working Gage Blocks		0.000,000,1"	NBS	NBS
Precision Surface Plates	0.000,020"	0.000,010"	NBS	
B&L DR 25 Gages	0.000,1"	0.000,010"	NBS	
Electronic Supermicrometer	0.000,010"	0.000,001"	NBS	
Internal Comparators	0.000,002"	0.000,001"	NBS	
Micro Ac Comparators ½ micro in.	0.000,000,5"	0.000,000,1"	NBS	
Kodak Optical Comparators	0.000,1"	0.000,010"	NBS	
Indi Ac Comparators	0.000,010"	0.000,001"		NBS
Para Ac Comparators	0.000,010"	0.000,001"	NBS	
Indi Ac Jr. Transistor Indicator	0.000,010"	0.000,001"	NBS	
Rockwell Hardness	1 point	0.5 point	NBS	
Auto Collimators	1/10 sec.	0.000,000,5"	NBS	
Plano Interferometers	1 fringe	0.25 fringe	NBS	
Thread Wire Set Masters		0.000,010"	NBS	NBS
Master and Working Optical Flats		0.000,001"	NBS	NBS
Monochromatic Light Sources	Hg^{198}, He, Kr^{86}		Light Waves	
Magnegages	0.000,050"	0.000,010"	NBS	NBS
Precision Barometers	0.01 mm	0.000,1 mm	NBS	NBS
Profilometers	0.000,000,1 rms	0.000,000,1"	NBS	
Plug & Thread Gages Master Set		1/10 Mil Spec.	NBS	
B&L Stereo Zoom Microscopes	7x to 30x			
Angle Gage Blocks	¼ sec.	1/10 sec.	NBS	NBS
Plugs, Micrometers, etc.		1/10 Mil Spec.	NBS	
Zeiss Optical Measuring Machine	30 sec. + 0.000,050	1 sec. + 0.000,001	NBS	
Working Thermometers	0.01°C	0.001°C	NBS	NBS
Zeiss Opton Interferometer**	0.000,000,1"	Light Waves		
Universal Measuring Machine**	0.000,010"	0.000,001"		
Dead Weight Testers**	6 lbs-12000 lbs.			
Dilatometers**	0.000,001"	0.000,001"		
Standard Measuring Machines**	0.000,010"	0.000,001"		
Precision Rotary Table**	1 sec.	0.1 sec.		
Triple Point of Water Apparatus**	0°C	0.01°		
Scleroscopes**	1 point	0.5 point		
Electronic Autocollimator**	1/10 sec.	0.000,000,5"		
Quartz Standards**	0.000,001"	0.000,000,1"		

*MetroLonics' Gage Block Sets are certified by the NBS. These gage block sets are the reference standards against which all linear measurements by MetroLonics' laboratory instruments are compared. Therefore, statement is made in column four of the table that "Ref. Stds. Used Calibrated by NBS." Several sets of gage blocks are kept in rotation between MetroLonics and NBS to assure current certification of the reference standards.

**To be added to laboratory.

JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION

President: *J. Marvin Lange*
Vice-President: *Ray D. Smoot*
Auditor: *Herbert L. Clark*
Program Chairman: *Robert D. Foster*
Secretary-Treasurer: *Glen C. Wilson,*
10219 *Orange Ave., South Gate, California.*

ROBERT C. HOFFMAN
Consolidated Electrodynamics Corp.

Continuous Stream Analyzers

In-plant process analyzers must be simple, reliable, provide component selectivity with minimum interference from other constituents, and require minimum maintenance. Here are typical analysis applications, problems, and results—in isobutane recovery, sulfur recovery, moisture monitoring, and closed-loop control via composition.

TODAY there is a wide acceptance of the fact that stream analyzers can be useful to almost every process stream where payout and product purity are important. Among the early techniques were infrared, pH, oxygen, and ultraviolet. They were first applied to such processes as acetylene production, refinery sewage disposal and acid sludge removal, catalyst regeneration, and butadiene purification. Today there are many types of stream analyzers available which offer attractive returns to the user—if he will but study their value.

Most continuous analytical process instruments cost from $2000 to $10,000 for a complete installation; elaborate systems can cost much more.

Payout will vary from about 1 month to 3 years. For example, at Sunray Mid Continent's Snyder Gasoline plant a $5000 instrument investment resulted in a $10,000 gain in propane recovery in one month; Magnolia Petroleum reported a saving of several thousands of dollars per month in a deisobutanizer-tower operation; Phillips Petroleum has this to say for an installation, "The instrument pays for itself every two weeks because of increased recovery of important constituents alone. It pays for itself every six weeks because of improved product quality."

Most installations pay for themselves in savings of utilities and steam alone, and there are other advantages. Continuous data permits an operator to see if the process is varying faster than the less-frequent lab samples can indicate. It also permits control to recover more rapidly by giving the first indication that the product is moving "off-spec."

10TH ANNUAL INSTRUMENT SHORT COURSE —SCMA and Los Angeles Harbor Junior College
DATE: Tues., March 28th, and Wed., March 29
PLACE: Los Angeles Harbor Junior College, 1111 Figueroa St., Wilmington, Calif.
April Meeting: April 20, Rio Hondo Country Club.
Subject: (1) Rotameters and (2) Thermocouples.

Deisobutanizer Tower Operation

A flow diagram of a deisobutanizer tower is shown in Fig. 1. Stream compositions are as follows.

	Input	Overhead	Bottoms
C_3	1.6%	2.5%	
iC_4	54.1%	81.3%	4.3%
nC_4	42.3%	16.2%	90.2%
iC_5+	2.0%		5.5%

The tower separates iso-butane (iC_4) from normal butane (nC_4). Normal butane is undesirable

TABLE 1—APPLICATIONS OF PROCESS ANALYZERS, BY TYPE

Instrument Type	Component	Concentration	Other Major Component	Plant	Service
Infrared	Acetylene	0 - 20%	Methane, Ethane	Air Separation	Partial Oxidation
Ultraviolet	Butadiene	0 - 10%	Butanes, Butylenes	Butadiene	Purification
Refractometer	Butadiene	3-1 Ratio	Styrene	Blending	Synthetic Rubber Feed
Moisture Monitor	Water	0-20 ppm	LPG	Refinery, Natural Gasoline	Monitoring of Moisture
Mass Spectrometer	Ethylene Oxide	0 - 50%	C_1, C_2, C_3	Natural Gas to Ethylene Oxide	Process Loops
Process Chromatograph	iC_4, C_4	0 - 5%	C_3, C_5	Refinery, Natural Gasoline	Butane Splitter
Paramagnetic	Oxygen	Range	CO_2, N_2	Refinery	Catalyst Regeneration

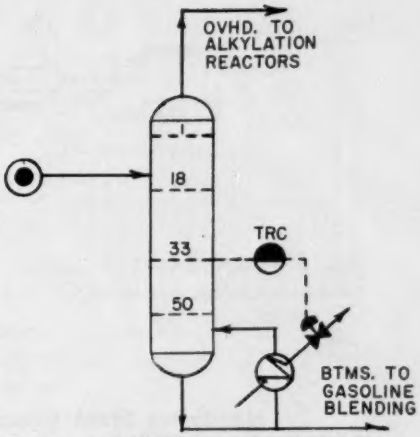


FIG. 1. DEISOBUTANIZER-TOWER. Most isobutane (ic_4) is in the overhead; the normal butane (nc_4) in the bottoms.

in the overhead because it acts as a diluent in the alkylation reaction between isobutane and olefins. Isobutane is undesirable in tower bottoms because it increases the vapor pressure of the tower bottoms, which are used to pressure motor gasoline. Each barrel of isobutane in gasoline displaces about 1.5 barrels of normal butane, resulting in a loss of total barrels of refinery gasoline.

However, some normal butane must go overhead and some isobutane must go out the bottom, the amount of each impurity depending on tower fractionation capacity and efficiency. Neither stream can be controlled for greater purity without sacrificing the quality of the other stream. The problem consists of evaluating the product streams to find an *optimum split* for maximum revenue gain, and then controlling the tower to maintain this split.

Economic Evaluation

Revenue is plotted versus volume (percent) isobutane in the tower bottom in Fig. 2. The curve is based on the cost of normal butane as a diluent in the alkylation reaction, and the revenue loss when isobutane is used for pressuring motor gasoline. The peak of the curve is between 3% and 4% isobutane in the bottoms product. Below this the alkylation reaction suffers. Above this amount (4% to 10%), too much isobutane is being taken out in the bottoms, with a resultant loss in pressuring gasoline.

Laboratory analyses were run to check the percentage of bottoms composition that fell in the desired range. Only 28% of the analyses showed the product to be in the desired range of composition. The process engineers realized that if the bottoms product could be analyzed every 10 to 15 minutes, the tower controls could be adjusted to maintain the desired split, and higher yield of the desired products would be realized.

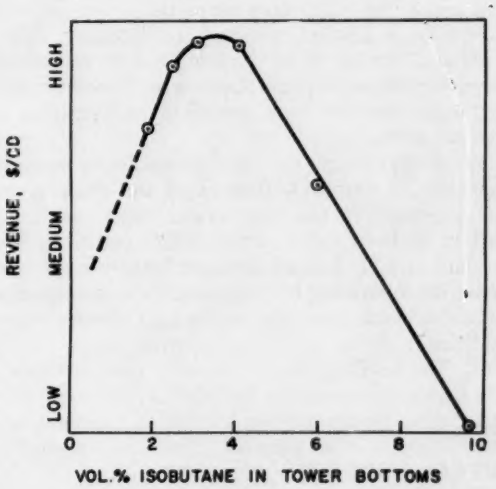


FIG. 2. REVENUE vs percent isobutane in tower bottoms.

Selection of Analyzer

Now that we have defined the problem, we can select an analyzer best suited to supply the necessary stream data.

Generally speaking, process analyzers can be divided into two classes—single- and multi-component analyzers. The single-component catagory includes optical-type analyzers (such as infrared and ultraviolet), refractive index and dielectric-constant analyzers, pH, oxygen and moisture monitors. Multi-component analyzers include the gas chromatograph and mass spectrometer. Examples of typical applications for each type are listed in Table 1.

Out of the many applications available for study, three are receiving much attention—oxygen, sulfur, and water.

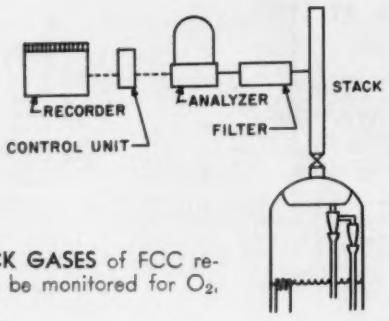


FIG. 3. STACK GASES of FCC regenerator can be monitored for O_2, CO and CO_2.

Monitoring Stack Gases of an FCC Regenerator

One application for *oxygen analysis* is that of monitoring the stack gases of the regenerator in a fluid catalytic cracking (FCC) unit (Fig. 3). Here a single-component analyzer checks the flue gases for oxygen (usually in the range of 0.1-1%) as an indication of regeneration efficiency. Excess oxygen means that (1) more air is being fed into the unit than is needed, resulting in excessive utility costs and (2) life of the cyclones can be shortened, requiring more frequent shutdowns. Too little oxygen indicates less than complete regeneration of the catalyst.

Recently, thought has been given also to monitoring the CO and CO_2 content of the stack gases. Air admitted to the regenerator reacts with the carbon on the catalyst, forming CO and CO_2. The amount of CO_2 formed depends largely on the regenerator operating temperature. In many applications the stack gases are fed to a CO boiler where additional air is added, converting more CO to CO_2. The resulting heat is used to generate steam. Therefore it is desirable that the CO content of the stack gases be maintained as high as practical, and the CO_2 as low as possible (the ratio approaches 20% CO_2 to 10% CO).

This application now requires a multi-component analyzer, such as a process chromatograph, to monitor the O_2, CO, and CO_2.

Sulfur Recovery

Improved efficiency in sulfur recovery is becoming increasingly important. In some areas of the country sulfur is needed to meet the demands of a growing steel industry; in areas such as Los Angeles closer regulation is required to lessen the air pollutants released to the atmosphere.

In the sulfur recovery process (Fig. 4), a feedstock rich in H_2S is burned in a waste-heat boiler to produce sulfur dioxide, which is reacted with additional H_2S to form H_2O and sulfur vapor. The sulfur vapor flows with the remaining gas to a condenser. The liquid sulfur is removed and the unreacted gases pass on to the second converter and condenser, and then to a coalescer and the stack, with liquid sulfur recovered at each stage. The reaction is:

$$H_2S \text{ plus } 1\tfrac{1}{2}O_2 \rightarrow H_2O \text{ plus } SO_2$$
$$2H_2S \text{ plus } SO_2 \rightarrow 3S \text{ plus } 2H_2O$$

From the second equation it is apparent that the H_2S and SO_2 should enter the reacter converter at a ratio of 2 to 1. Any deviation from this ratio in the converter shows as an excess of either H_2S or SO_2 in the stack gases. This means inefficient operation of the waste-heat boiler in producing SO_2.

The accepted method for maintaining the proper ratio was chemical analysis. At one plant samples were taken every two hours; it was determined that the resultant delay in obtaining the analysis resulted in a plant efficiency of only 85%. On-stream checks with a *mass spectrometer* indicated that a process analyzer reporting the ratio every 15 minutes would make it possible to achieve closer control, greater sulfur yield, and less air pollution.

The flow of feed stock to the waste-heat boiler and the converter is controlled by ratio-flow recorder/controllers, which also control the flow rate of air to the boiler. The difficulty is that the percent H_2S in the feed stock varies, thus upsetting the ratio of H_2S-to-SO_2 flowing into the converter. Fortunately, this ratio can be monitored in the stack gases, and a correction made in the flow rate of air to the boiler to reduce or increase the rate of SO_2 generation.

A *process chromatograph* was selected as the simplest and most straight-forward means of monitoring the stack gases.

The biggest problem was in designing a sampling system which would not plug with sulfur and could handle the entrained water. The system was designed by close cooperative effort between supplier and user. With frequent chromatographic analysis, one operator of a 50 ton/day plant realized an increase yield of 6 tons/day.

Moisture Monitoring

Moisture in process streams has long been a problem, requiring dehydrators and treaters for its removal. For example, at Shell Chemical's plant in Torrance (California), moisture in the crude ethylene feed stock to a demethanizer can cause freeze-up in the fractionating columns at an operating temperature of −100°F (Fig. 5). Three dryers (filled with Florite dessicant) are in the feed line. One is being regenerated with hot, dry gas. Slowly the alumina oxide loses its effectiveness, until finally the daily regeneration cycle is no longer effective. At this point the dessicant must be replaced. As a safety factor, the dessicant was replaced well in advance of its useful life.

Now a process moisture monitor monitors the effluent of the dryers; when the moisture content reaches 20 PPM the dessicant is replaced. The monitor has shown that the useful life of the dessicant is eight to nine months—resulting in savings of several thousand dollars over a two-year period. Payout on this basis alone is about one year.

The ethylene feed stock need not be monitored continuously because the moisture content changes

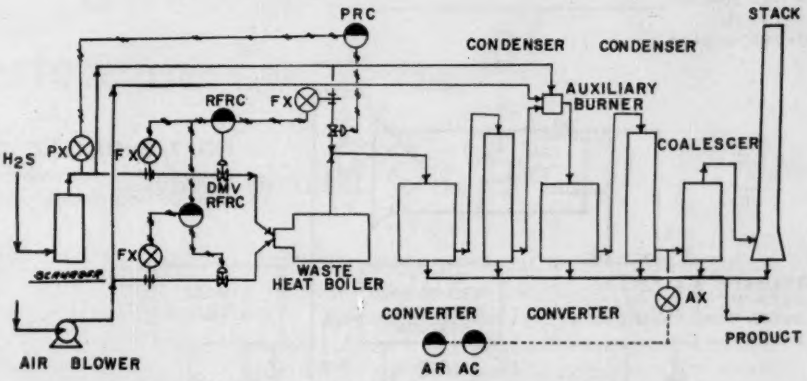


FIG. 4. SULFUR RECOVERY plant first burns H_2S (in boiler) to produce SO_2; the SO_2 combines with more H_2S in converters, to form sulfur vapor. FX are flow transmitters; RFRC are ratio-flow recorder-controllers. PX is pressure transmitter; AX is analyzer transmitter; AR is analyzer recorder; AC is analyzer controller.

slowly. The overhead and bottom products of the ethylene-ethane splitter also are monitored (1) to catch tramp moisture which may have crept in, and (2) to prevent heat loss due to the formation of hydrates.

Another application for moisture determination includes the feedstock to a catalytic reforming unit, where moisture in the liquid stream causes the formation of chlorides which leach out the catalyst. Here a liquids moisture monitor checks the effectiveness of the pretreater, signalling the need for corrective action before valuable catalyst is ruined.

Closed-Loop Control

After successfully applying a process stream analyzer, the question arises whether further economies can be realized if the control loop is closed.

In natural-gasoline-plant operation, revenue is gained by the sale of the liquefied natural-gas products removed from the gas in the oil well, along with the subsequent sale of the uncondensed portion of the gas. Industry standards limit the composition of the product by tests which limit the concentration of the heavier-than-propane components to approximately 1%. The lighter-than-propane components are limited by the maximum-vapor-pressure specification.

These "lighters" are mostly ethane, and their tolerances are not set because, in order to produce the maximum possible quantity of propane product, it is advantageous to include as much ethane in the product as the vapor-pressure specifications will allow and still not exceed the maximum 210-psi allowed.

In one such plant (Fig. 6) the de-ethanizer is the first column in a fractionating train of four columns, and its stable operation directly influences the stable operation of the others. The usual method of controlling such a tower operation is to use a temperature controller on a tray near the bottom. However, it was found that the feed-composition and feed-rate variations resulted in temperature control that, at best, allowed the resulting propane-product vapor pressure to vary from 190 to 225 psi, with an average vapor pressure of 202 psi.

The user estimated that if the ethane content of the 202-psi vapor-pressure propane were controlled

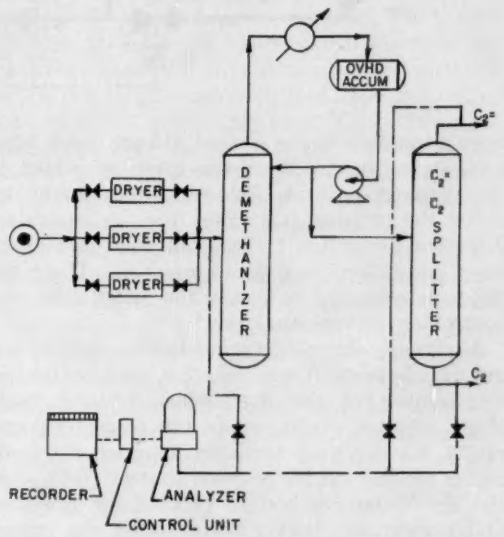
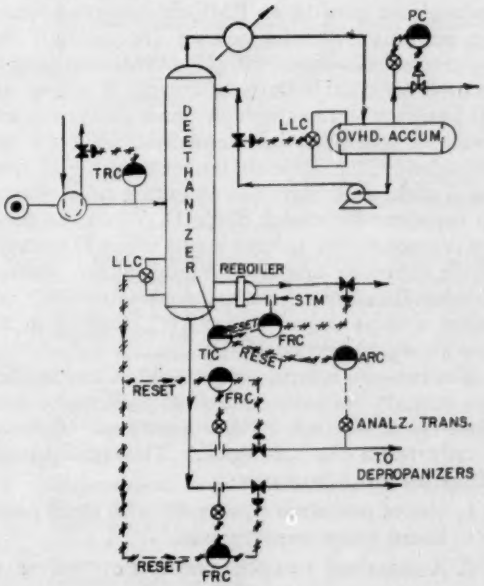


FIG. 5. MOISTURE MONITOR shows when dryer dessicant should be replaced.

FIG. 6. CONTROL of de-ethanizer column from product composition.



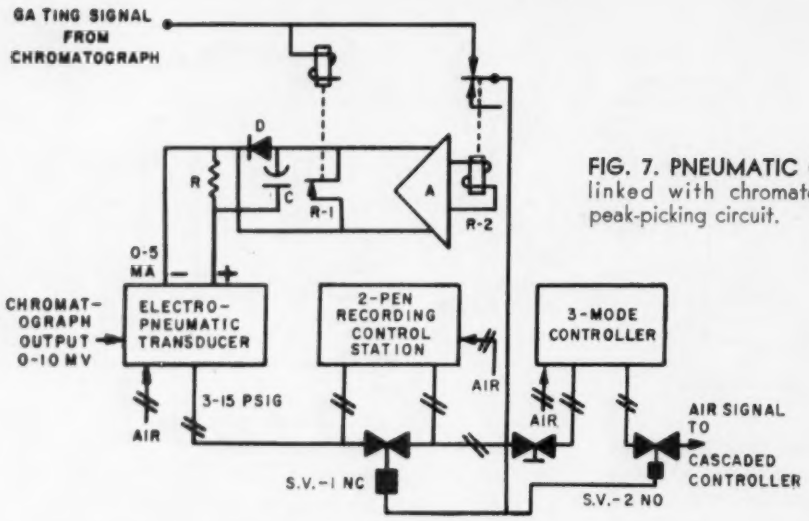


FIG. 7. PNEUMATIC CONTROL linked with chromatograph via peak-picking circuit.

more accurately to the desired 210-psi vapor pressure, an additional 2% ethane could be added to the propane product. Achieving this would increase the propane sale value from an equivalent 0.39 cent per gallon (when sold as a gas) to 4.0 cents per gallon (as propane product). These calculations appeared to justify the installation of a controlling process analyzer.

A *process chromatographic control system* was installed because it was felt that composition determinations of the deethanizer bottoms every thirty minutes would satisfy the control requirements, leaving time available to monitor the absorber residue gas for propane content (0-5%), and the deisobutanizer bottom product for isobutane and isopentane (0-5%). Fig 6 shows the process loop and the associated controls.

Of particular interest is the adaption of the analyzer's signal to closed-loop control. The user wanted pneumatic control. The 0-10 mv output signal from the analyzer goes to an EMF-air converter which has been modified for storing (or picking) the key control component (Fig. 7). When the peak to be used for control starts to emerge, a gating signal from the chromatograph opens relay R-1 and solenoid valve SV-1, and closes SV-2. SV-2 is a cut-off valve which locks-in the output signal from the 3-mode controller. The emerging peak charges up capacitor C through diode D. When the peak-top is reached, the voltage across diode D reverses, which (through amplifier A) opens the contacts of relay R-2. This closes solenoid valve SV-1 and (after a short delay) opens SV-2, locking in the new air signal beyond SV-1.

The two-pen control station used in this application records both the controlled peak and a complete chromatogram. (The ethane peak of stream 1 only resets the air signal.) This configuration offers several advantages:

1. Use of miniature equipment with small panelboard space requirements.
2. A standard two-pen pneumatic receiver records both the chromatogram and the controlled peak, if desired.
3. Complete three-mode control—proportional, reset and rate action. The three-mode controller contains a special non-overpeaking pneumatic circuit.
4. Option of either pneumatic or electrical output signal. Records of the vapor presure of the propane product taken over several months indicate an average vapor pressure of 209.5 psi with respective maximum and minimum values of 214.0 psi and 207.0 psi. With the increased yield of propane, it was calculated that the cost of a controlling chromatograph would be amortized in six months.

Computer Control

Some processes do not lend themselves to simple closed-loop control. The effect of the many variables is so complex that a computer acting as a mathematical model of the process is required. All of the proper variables are fed into the computer, which resets key operating parameters to optimize production of the desired product.

One such process involves the production of vinyl chloride from ethylene and chlorine. The method requires two steps in the operation to produce dichlorethane, which is then thermally cracked to vinyl chloride.

The ratio of dichlorethane/vinyl-chloride in the thermal-cracking step is important to this process. One company has elected to monitor both of these constituents and feed the ratio to a computer. A process chromatograph was selected as the analyzer with a sampling system monitoring the following composition:

Dichlorethane—30%
Vinyl Chloride—30%
Hydrogen Chloride—Balance
Water—50 PPM

A peak-picking circuit was added to the control system for the chromatograph to obtain the ratio of dichlorethane/vinyl-chloride.

Interference Comparator

DR. JURGEN WITTHOFT

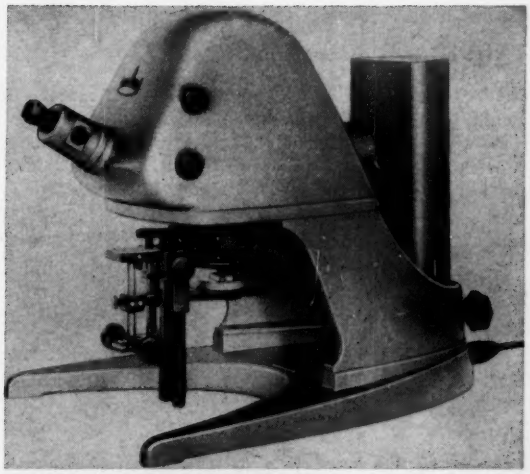


FIG. 1. INTERFERENCE Comparator IC after Duhmke for gage blocks. (Photo courtesy Askania-Werke)

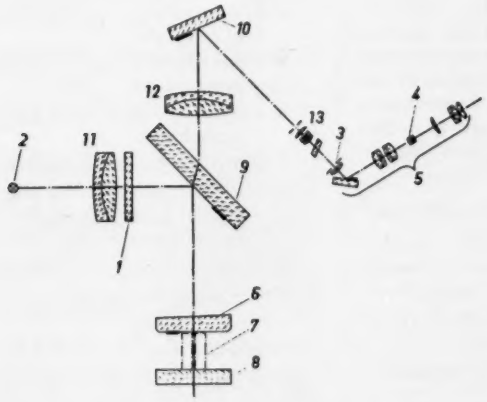


FIG. 2. PRINCIPLE is based on multiple interferences between wedge-shaped comparison plate (6) and gage blocks (7), and two-beam interference between wedge (6) and optical flat (8). Lamp source is (2).

FIG. 3. EXAMPLES of comparisons that can be made with the Interference Comparator. The standard gage block is on the lefthand side of each illustration, the specimen on the righthand side.

THIS INTERFERENCE COMPARATOR of the Duhmke type for gage blocks determines differences in the length of gage blocks by means of contrasty multiple-beam interferences, and checks parallelity and smoothness of the measuring surfaces (surface irregularities).

Despite its high measuring accuracy, the instrument can be operated easily. With a setting for eight fringes, there is a reading accuracy of 0.002 μ when two lengths are compared. The measuring accuracy when comparing gage blocks is better than 0.01 μ. With an accuracy of ± 0.02 μ of the standard gage guaranteed by governmental testing laboratories, the accuracy that can be achieved with this instrument is better than 0.03 μ.

The measuring principle (Fig. 2), making differences from the standard visible, makes other corrections unnecessary (such as temperature, humidity, air pressure).

As a multiple-beam interferometer this instrument may be used for topographic investigations of coated surfaces and related tasks for which a depth resolution of 100 angstroms can be achieved.

Typical patterns (Fig. 3) are interpreted as follows:

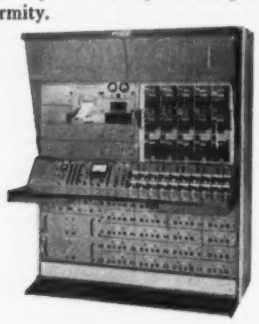
Figure	TEST RESULT	INTERPRETATION
A	The interference fringes on the specimen have the same direction as those of the master gage but are spaced more closely.	The measuring surfaces of the specimen are not parallel in longitudinal direction.
B	The interference fringes on the specimen are spaced equally as those of the master gage but have a different direction.	The measuring surfaces of the specimen are not parallel in transverse direction.
C	The interference fringes on the specimen are irregular (jagged)	The measuring surfaces of the specimen are not parallel in both directions and damaged mechanically (grooves)
D	The interference fringes on the specimen run in the same direction as those of the master but the interference systems are displaced relative to each other.	The surface of the specimen is in order (parallel) but differs in length.
	The displacement of the interference fringes shown can be determined by means of a reticle in the microscope.	
E	The interference fringes on the master gage and the specimen are the same and not displaced with respect to each other even when different filters are used.	The specimen is in order (parallel)

EAI

experience in depth... *computing, plotting, instruments, systems, process control*

ANALOG PROCESS SIMULATION CAN MULTIPLY PROFITS

Extensive process industry experience has proved that EAI Model 231R Analog Computer can make major contributions to profits. Through the use of this versatile analog computer, both in process and controls simulation, optimum utilization of existing plant can be attained. In addition, planned construction can be designed for lowered investment and production costs, improved output and product uniformity.



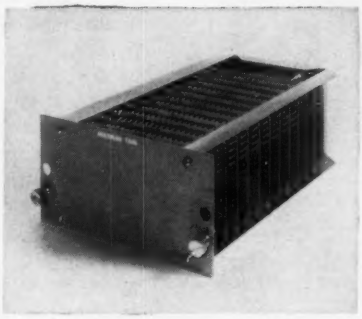
Applications in which EAI Model 231R Analog Computer Systems have proven invaluable include:

- New process research and development
- Process equipment design
- Pilot plant scale-up
- Control system design
- Optimum yield studies
- Chemical kinetic studies

Dozens of EAI analog computer installations are today producing profitable results in process industries. Over 100 problems in process simulation have been solved by EAI Computation Centers for 38 companies in the processing industries. This experience and capability is available to assist you in developing more profitable solutions to your process development and control problems. For complete information on EAI equipment and services, write to Department 21.

ULTRA FAST AND ACCURATE ELECTRONIC MULTIPLIERS

Part of a new generation of electronic multipliers, designed and developed by EAI, the new Multiplier Model 7.036 combines unusually wide bandwidth with high static accuracy.



Virtually maintenance-free, the Multiplier 7.036 utilizes a unique quarter-square technique that achieves high static multiplying accuracy without the usual resulting deterioration of frequency response. Diode function generators develop the square quantities from x and y imputs, eliminating the need for internal amplifiers.

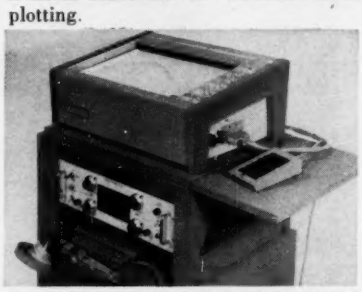
Here are the outstanding features of this new multiplier:

- Outstandingly low output noise—20 millivolts maximum
- Solid state design insures reliable operation
- Holds calibration for extended periods
- Frequency response—over 20 kc
- Static accuracy 0.04%—Zero error 0.01%
- Drift-free, internally temperature-compensated
- Can be added to expand existing systems without modification

For specific details on the EAI Multiplier 7.036, write to Department 22.

DIGITAL PLOTTING—WITH ACCURACY AND LOW COST

Dramatic improvement in the accuracy of 11 x 17 inch X - Y plots of digital data is now available with EAI Series 3100 DATAPLOTTER. The low cost of this instrument makes available a rapid and economical substitute for laborious hand plotting.



Outstanding features of EAI Series 3100 DATAPLOTTERS include:

- System accuracy up to 0.175% of full scale
- Punched card, tape or keyboard input
- Plotting speeds up to 80 points per minute
- Provisions for "off-board" origin
- Compact, self-contained single cabinet design. Punched card reader external.
- Adaptable to any computer system
- Accepts analog as well as digital inputs

Transistorized control circuitry insures high-speed, accurate, reliable operation. The EAI Series 3100 DATAPLOTTER makes readily available a low-cost tool for fully exploring experimental design problems. It is particularly applicable in data reduction and instrumentation installations. As a management tool, it is valuable for the conversion of computer intelligence to graphic representation of sales, production and cost data.

For details on the Series 3100 DATAPLOTTERS, write to Department 23.

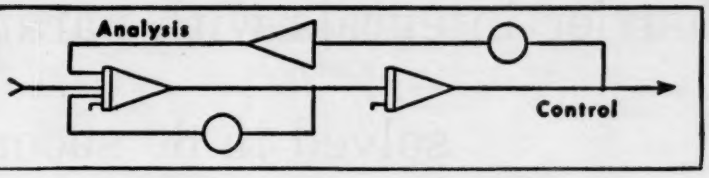
Career Opportunity for Engineers—Graduate or advanced degrees in EE, Physics, Math—call or write Gordon Strout, Director-Personnel

EAI *See us at Booth Nos. 3712, —14, —16, —18 at the IRE Show, March 20—23*

ELECTRONIC ASSOCIATES, INC. | LONG BRANCH, NEW JERSEY

FOR ANALOG COMPUTER—CIRCLE 88 FOR MULTIPLIER—CIRCLE 89 FOR DATA-PLOTTER—CIRCLE 90

SIMULATION COUNCIL



Newsletter

John H. McLeod Jr., EDITOR

Suzette McLeod, SECRETARY

8484 La Jolla Shores Drive,
La Jolla, California

Simulation Councils, Inc.

Jack Sherman, Lockheed Aircraft Corp., Sunnyvale, Calif.; Chairman, Board of Directors

Jack Sherman

Hans Meissinger

Western Simulation Council

Hans Meissinger, Hughes Aircraft Company, Culver City, Calif.; Chairman, Steering Committee

Midwestern Simulation Council

P. J. Hermann, Iowa State University, Ames, Iowa; Chairman, Steering Committee

P. J. Hermann

Maughan Mason

Rocky Mountain Simulation Council

Maughan S. Mason, Thiokol Chemical Corporation, Brigham City, Utah; Chairman, Steering Committee

Southeastern Simulation Council

M. E. McCoy, Jr., Martin Co., Orlando, Fla.; Chairman, Steering Committee

Central Simulation Council

Thomas R. Herndon, Humble Oil & Refining Co., Baytown, Texas; Chairman, Steering Committee

Eastern Simulation Council

William F. Blodgett, Electronic Associates, Inc., Long Branch, N. J. Chairman, Steering Committee

DDA Council

Rudolf Rutishauser, Litton Industries, Canoga Park, Calif.; Secretary, Board of Directors

Bits

This month under **PIECES** we give you **Maughan Mason's** brief Brief on the Rocky Mountain SC's White Sands Missile Range meeting of 12/5/60. **Gunther Hintze** told about preventive maintenance at White Sands: **Gilbert Grado** described Euler Angle conversion; **William McCool** spoke on a special-purpose computer for determining transfer function coefficients; and **Tomio Katsura** described methods used in simulation of electronic environments.

Also under **PIECES** are two versions of the 12/12/60 meeting of the Eastern SC held at Computer Systems Inc., one by this month's "Guest Editor," **Allan Wilson,** and the other by the speakers themselves as quoted (out of context) by ye Ed. The papers covered are: "Utilizing the Operational Amplifier with Dynamic Storage as a General-purpose Non-linear Element," **J. M. Andrews;** "Solutions of Bounded Fourier Integrals on the Dystac® Computer," **J. M. Nelson** and **Stanley Fried;** "A Non-linear Programming Technique for Analog Computation," **J. H. Moser, C. O. Reed,** and **H. L. Sellars;** "Application of Repetitive Operation and Dynamic Storage to Industrial Process Control System Design," **B. H. Baldridge** and **G. Van Wagoner.**

We also are furnishing an Info item concerning a source of info, and some additional data on SCI activities.

My mail box has no **LETTERS,** my mind no **THOT**—and if **HE WENT,** he didn't let me know!

Pieces

ROCKY MOUNTAIN S/C MEETING OF 5 DEC. ON EULER ANGLES, TRANSFER FUNCTIONS AND ENVIRONMENT SIMULATION

We are indebted to **Maughan Mason,** Chairman of the Steering Committee of the Rocky Mountain Simulation Council, for the following brief account of their meeting.

"On 5 December 1960 the Rocky Mountain Simulation Council met at White Sands Missile Range with 33 in attendance.

"Mr. **Gunther Hintze,** Chief of the Flight Simulation Laboratory and host for the meeting, welcomed the group. In his introductory remarks he mentioned the WSMR, feeling that preventive maintenance pays large dividends, and mentioned an 80-90% project utilization of his analog facility.

Euler-Angle Computer

Mr. **Gilbert Grado** described the Euler-angle-conversion computer designed by WSMR for high-accuracy coordinate transformation. There are six units, each with 11 sine formers, 33 amplifiers (including 3 integrators), 26 multiplication products, and one division. The multipliers are of the time-division type. Components are mounted in a constant-temperature oven, and are permanently committed, although modification to permit "borrowing" is being considered through use of an auxiliary patchboard.

Ten to twenty cycles per second is the upper frequency range, over-all accuracy is approximately 0.01% (compatible with other equipment used), and relay switching is felt to be the major error. Three to four of the units are in nearly constant use. All components are rotated and checked every three months as part of the preventive maintenance procedure.

McCool on Transfer-Function-Coefficient Analyzer

William A. McCool spoke to the group on development of a special-

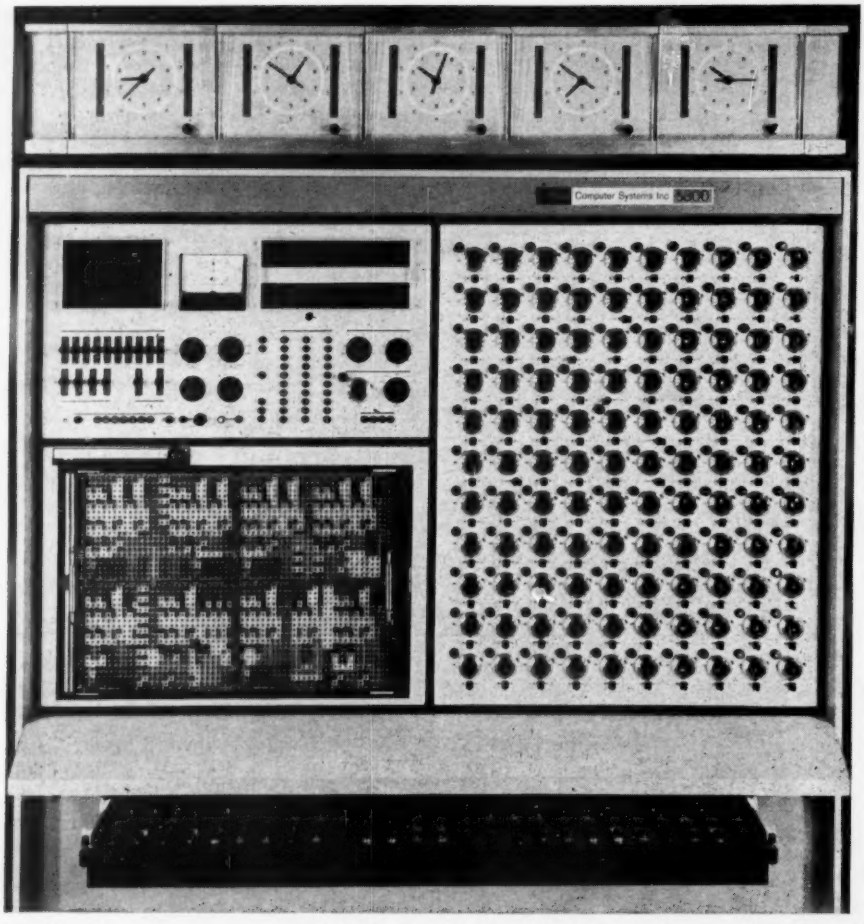
Fourier integrals with parameter variations

$$A(u)\ \text{real} = 2\int_0^1 f(x)\left[\cos\left[(\psi(x)+ux)\right]+\cos\left[(\psi(x)-ux)\right]\right]dx$$

solved in 60 seconds...

$$A(u)\ \text{imaginary} = 2j\int_0^1 f(x)\left[\sin\left[(\psi(x)+ux)\right]+\sin\left[\psi(x)-ux\right]dx\right]$$

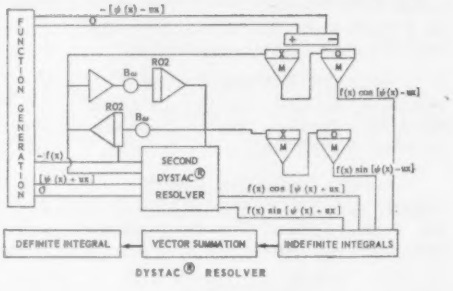
with DYSTAC® 5800 Analog Computer



Chemical process evaluation, microwave antenna design, aircraft and missile design...these are but a few of the parametric studies that DYSTAC, and only DYSTAC, can perform. DYSTAC 5800 is the only analog computer with a memory and high-speed repetitive operations. These two unique capabilities allow the 5800 to make rapid solutions to problems that would otherwise require error-producing over-simplifications.

Unlike other analog equipment, the DYSTAC 5800 utilizes time-sharing of components, thus greatly decreasing the size and cost of the computer relative to its capability. The high-speed rep-ops, together with dynamic storage of analog data, give the machine the best features of analog *and* digital computation. It is the only computer capable of solving equations with two or more independent variables in 60 seconds or less. In addition, it assures data storage accuracies of 0.01% and a time-base accuracy of ± 0.5 μsec.

Send for our 11-page report, "Solutions to Bounded Fourier Integrals on the DYSTAC Computer."



COMPUTER SYSTEMS, INC., Culver Road, Monmouth Junction, N. J. • DAvis 9-2351

A Schlumberger Subsidiary • formerly Mid-Century Instrumatic Corp.

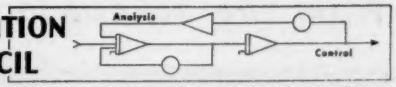
CIRCLE 91 ON READER-SERVICE CARD

purpose computer for determination of transfer-function coefficients from transfer-function excitation and response data.

Given a transfer function with an arbitrary number of terms in numerator and denominator, initial conditions can be assumed zero, and s considered to be the differential operator. Then, by suitable sampling of system input and response, numerical differentiation techniques may be employed to obtain necessary derivatives, and the transfer-function coefficients can be determined. This method can be used to determine slowly varying coefficients as functions of time, even though use of the transfer-function methods implies linearity.

This technique has applications in adaptive systems, sophisticated flight analysis, and process control studies, with noise being a major problem.

SIMULATION COUNCIL



Katsura on Electronic Environment and Radar Simulation

Tomio Katsura described methods being used in simulation of electronic environment and radar systems in connection with guided-missile simulation at White Sands Missile Range. He pointed out areas being investigated, applicable techniques being utilized, and indicated the detail possible on such simulations.

Following the technical and business meeting, the group toured the Flight Simulation Laboratories computer facility, consisting of an IBM 704 and approximately 900 amplifiers of analog equipment.

TOMIO KATSURA, BA, Physics, U. of Cal. at Berekeley, has experience in high-power radar design (MIT), radar techniques (Moore School of EE, U. Of Penna.). He has been engineer of chain-radar instrumentation systems for missiles at White Sands Missile Range for 6 years.

EASTERN S/C MEETING OF 12 DEC AT COMPUTER SYSTEMS

Allan Wilson, a colleague of your Ed's whom we have quoted in these columns before, wrote a trip report which we believe is quite interesting —partially because it was not written for publication! However, with some misgivings he gave us permission to use parts of it provided we would take the blame for any misinterpretations of what actually was presented. So we quote:

"The Eastern Simulation Council met on 12 December at the facilities of Computer Systems, Inc. at Dayton, N. J. (near Princeton, N. J.). The one-day meeting was scheduled to start at 10 A.M., but the prevalent blizzard conditions delayed the opening until around 3 P.M. Despite the weather, however, it was well attended by some 60 or 70 persons.

"The papers presented at the meeting demonstrated that the Dystac-* type computer has considerable versatility of application. In addition to presenting a new method for solving conventional analog problems, the speakers showed that the system can be used to good advantage in the design of process control systems.

Andrews on Non-Linear Elements

"Easily the most intriguing paper was the opener, in which it was shown how operational amplifiers, memory amplifiers, and electronic switches have been teamed up to produce general non-linear elements with excellent frequency response. Non-linear mathematical operations which have been programmed include (1) 4-quadrant multiplication, (2) 4-quadrant division, (3) trig function generation, (4) inverse trig functions, (5) polynomial function generation, and (6) power generation.

JACK ANDREWS, B.S. M.S., Chem Eng., Texas A&M College, is Industrial Sales Mgr. of Computer Systems, Inc., since 1959. For 11 years, he was Staff Eng., applied math, Humble Oil & Refining, Baytown.

"The general principle is simple. Basically a problem is run as an ordinary analog, so far as the handling of the problem variables entails integration or summation. But mathematical operations upon these variables, such as those described in the preceding paragraph, make use of sampling of a high-speed repetitive analog-circuit function-generator. Suppose, for example, a problem is running at a rate of one cycle/second, and it is necessary to have available the sine of the problem variable. Then a separate analog loop which generates a high frequency sine wave (say 100 cps, on up) is employed. A time base is set up for this higher frequency generator which is proportional to the basic problem variable, and the value of this sine function is *sampled* at the appropriate instant in time. Accordingly the sine value may be sampled many times during the cycle of the basic problem, and one needs only to adjust frequencies so that sufficient samples per second are taken so that reasonably smooth function-generation results.

"The key to this technique is the use of electronic switches rather than relay-operated switches. Thus timing pulses of order 10 microseconds are one of the limiting factors in this method, as opposed to relay closure times that are 1000 times longer.

Nelson and Fried on Bounded Fourier Integrals

"The second paper dealt with the evaluation of a particular Fourier integral as arises in the evaluation of the radiation power pattern for a microwave antenna. The main purpose was to show that the Dystac could be used to evaluate messy integrals, such as

$$\int f(x)\{\cos[u(x) + v(x)] + \cos[u(x) - v(x)]\}dx.$$

Moser, Reed and Sellars on Programming

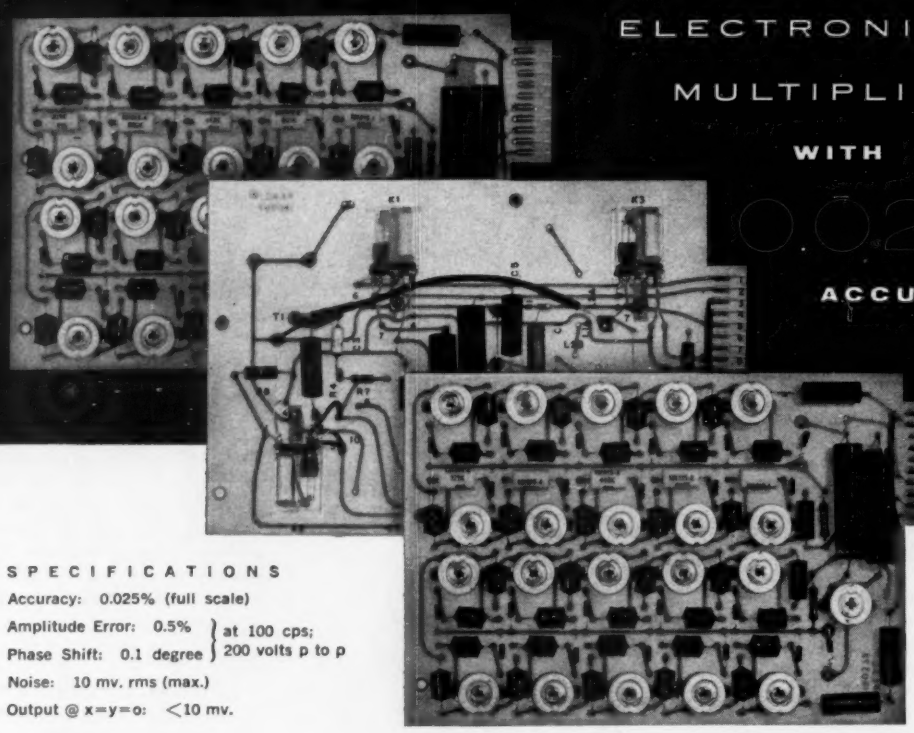
"The third paper described the application of Dystac to the optimization of a gasoline production process. The problem was to find the best val-

*See "The Dynamic Storage Analog Computer—Dystac" in the "Analog Issue" of *I&CS*, Volume 33, No. 9, September 1960.

from the acknowledged leader in analog computer design

REAC®

SOLID STATE ELECTRONIC MULTIPLIERS WITH 0.025 ACCURACY



SPECIFICATIONS

Accuracy: 0.025% (full scale)

Amplitude Error: 0.5% } at 100 cps;
Phase Shift: 0.1 degree } 200 volts p to p

Noise: 10 mv. rms (max.)

Output @ x=y=o: <10 mv.

MULTIPLIER CONSOLES

1. Eight Independent Products.
2. Expandable to 16 Products with adapter kit.
3. Adequate power for expansion to 16 products.
4. Operational Amplifier for each product.
5. Amplifier Balance Meter.
6. Standard Rack Mounting.

WITH THESE OUTSTANDING FEATURES:

- FOUR QUADRANT MULTIPLIER
- EXTREME DYNAMIC RANGE
- TEMPERATURE COMPENSATED
- FACTORY CALIBRATED, NO FIELD ADJUSTMENTS
- SILICON JUNCTION DIODE SHAPING NETWORKS
- PRINTED CIRCUIT PLUG-IN CARDS

For complete specifications, write for data file 603.

Qualified engineers seeking rewarding opportunities in these advanced fields are invited to get in touch with us.

Reeves

REEVES INSTRUMENT CORPORATION

A Subsidiary of Dynamics Corporation of America • Roosevelt Field, Garden City, N. Y.

See our dynamic display at the **I.R.E.** Exhibit—Booths **1305—1307**

CIRCLE 92 ON READER-SERVICE CARD

JOE M. NELSON has an M. S., Chem. Eng., U. of Oklahoma. He was Chem. Eng. with DuPont, is now Applications Engineer with Computer Systems, has written book Operation of the Analog Computer.

ue of "residence time" in the chemical reactor *and* the best value of inlet temperature, in order to maximize "profit" while producing gasoline subject to the constraint of a minimum octane number. In general terms, the idea was to maximize a function of several variables, subject to certain constraints. The Dystac was programmed for an iterative process whereby it zeroed in on a condition of zero gradient for the function. At an iteration rate of 50 per second, it is only a matter of minutes for the machine to locate an optimum. Accordingly the Dystac appears to have good potentialities as a "process simulator" in the design of chemical process systems. Digital computers are widely used for this purpose too, but in highly non-linear systems this analog approach has certain advantages.

Baldridge and Van Wagoner on Power Stations

"The fourth paper was given by **Bruce Baldridge** of the Control Systems Division of Daystrom, Inc., in La Jolla. They are one of the first customers for the Dystac 5800 computer, and have used it to very good advantage in the design of a power station in Louisiana which will have completely automatic analog and digital control devices.

"Dystac was used in two important phases of the power plant simulation. First, it was used as an ordinary analog computer for evaluation of power-plant transients and determination of power-plant transfer functions. (Use of the repetitive operation feature was considered to have saved substantial time over what would have been required to do the same analysis on an ordinary analog computer—of which they had one, for use in other phases of the work.) The second phase was in the use of the Dystac to simulate their digital control computer. The sampling technique in the Dystac can be used to imitate periodic digital signals, and it is in this connection that Dystac appears to have strong potentialities for design of process control systems.

"The fifth paper scheduled ("A New Analog Computer Technique in the Solution of Partial Differential Equations" by **Stanley H. Jury,** University of Tennessee, Knoxville, Tenn.) was not given, due to lateness of the hour and absence of the principal author. It was to deal with the use of Dystac for solution of a partial differential equation for heat flow in a slab. This is another area in which high-speed repetitive operation offers possibilities of new advances in computing techniques.

"The meeting ended about 7 P.M. and was considered by most observers as having been a very constructive session. Although the Dystac Computer was being pushed, everyone looked on the session as an exposition of a new computing technique—and as such it was well received. My own personal opinion is that they have something there, but it will be a little while before we know what their limitations of accuracy and scope will be."

To amplify and perhaps modify the foregoing impressions as expressed by Allan, I would like to present some excerpts from the papers as written. (Copies of all five papers presented can probably be obtained by writing **J. M. Andrews,** Sales Manager, Computer Systems Inc., Dayton, New Jersey.)

By way of introduction, **J. M. Andrews,** in his paper "Utilizing the Operational Amplifier with Dynamic Storage as a General-Purpose Non-Linear Element," stated:

Andrews (again) on Non-Linear Elements

"The Analog Computer, although a valuable tool from its origin, has often been limited when solutions to problems containing non-linearities were attempted. This limitation was especially acute since most phases of engineering and scientific work consist of problems containing non-linear equations.

"The effectiveness of the Analog Computer, however, was rapidly increased with the many advances in the approach to non-linear phenomena. Equipment capable of performing multiplication and division, and generating arbitrary, trigonometric and other varieties of non-linear expressions, has become an inherent part of the Computer System. These devices perform reasonably well and in that sense "fill the need," but they also have limitations which are incompatible with latter-day computation techniques. The newer High Speed Repetitive Operation Computer, for example, is ultimately limited in that its speed of operation is dependent upon the acceleration which can be imposed on the active elements.

"Present developments utilizing High Speed Repetitive Operation and Memory devices can be used to minimize the problems encountered with simulations containing non-linearities. This paper discusses several non-linear applications utilizing High Repetitive Rates of operation (Rep-Op) and Dynamic Storage Analog Computation (DYSTAC®). These applications are especially important in that they are accomplished within the confines of the Analog Computer proper utilizing the basic operational amplifier and containing no non-linear auxiliary enclosures or devices.

"The non-linear applications described utilize a basic technique made possible only with the new analog-computation tools featuring Repetitive Operation and Dynamic Memory. *The technique provides for the conversion of a variable, normally generated as a function of time, to a function of a dependent variable.* The versatility of this approach suggests its use for many other applications in addition to those outlined.

This paper emphasizes the flexibility of the DYSTAC® computation tool by describing its ability to perform:

a. Four-quadrant Multiplication
b. Four-quadrant Division
c. Sine, Cosine generation
d. Arcsine, Arccosine generation
e. Generation of any function expressed as a polynomial
f. Power Generation

To convert a variable, normally generated as a function of time, to a function of a dependent variable, the computer is connected as indicated in Fig. 1.

A high-speed comparator is wired to accept two inputs, a rep-op ramp D and a function of a dependent vari-

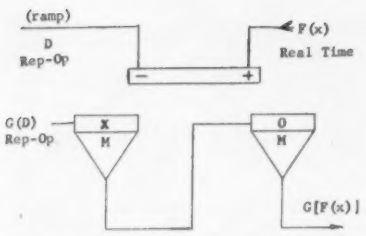


FIG. 1. CONVERTING a variable to a function of a dependent variable.

able, F(x). The X memory circuit learns a signal G(D), the variable to be converted. Upon coincidence of the two comparator voltages both memories are triggered, therby locking the X memory on the value G(D), where D is equal to F(x). The O memory learns this value, which is now effectively G[F(x)], and makes it available as the final output.

In order to accomplish a point of comparison between the ramp function D and the dependent variable x, it is necessary for the ramp to sweep between the minimum and maximum possible values of the dependent variable F(x) in one rep-op cycle. This is accomplished by placing +100 volts in the initial-condition input, thus causing the integrator output to start from −100 volts and integrate to +100 volts in one repetitive cycle (Fig. 2).

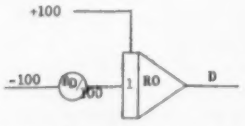


FIG. 2. INTEGRATOR starts at −100 volts and integrates to +100 v in one repetitive cycle.

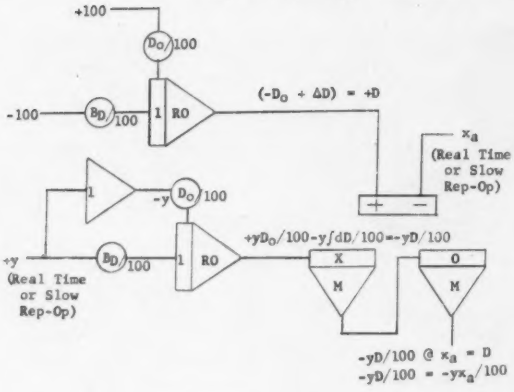
Many applications are derived from this basic technique of conversion from functions of time to that of a dependent variable.

Four-Quadrant Multiplication

Four-quadrant multiplication within the accuracies of servo multipliers but without their frequency and stability limitations is made possible with these techniques. Fig. 3 is the mechanization required for this.

To multiply y by x_a, the variable y is introduced into the rep-op integrator through the normal input and also, after inversion, to the initial-condition input. This variable y is generated from a real-time or slow rep-op source, and upon entering the rep-op integrator effectively becomes

FIG. 3. FOUR-QUADRANT multiplication.



a constant. This produces an integrator output of $+yD_o/100$—y times the integral of the rate of change of D/100 or the ramp $-yD/100$ starting from an initial condition $+yD_o/100$ and decreasing to $-yD/100$. This ramp enters the memory stages where it is tracked by the X memory. The coincidence of the second ramp D with x_a at the comparator triggers the X and O memories, allowing the O memory to track the last value at the X memory. The final output $-yD/100$ occurs when $x_a = D$ and is therefore equal to $-yx_a/100$, the product (with sign inversion) we wish to produce.

The two ramps used in this mechanization must be produced from integrators whose rates of integration are identical. This is accomplished by setting the two B_D potentiometers to the same value to insure that the output ramps go through zero at the same time and vary from minimum to maximum in one rep-op cycle. Fig. 4 shows all the curves involved in the evaluation of the final product which occurs at the time of comparison of the variable x_a and ramp D. Note that x_a is shown graphically as a constant since the rep-op sampling frequency

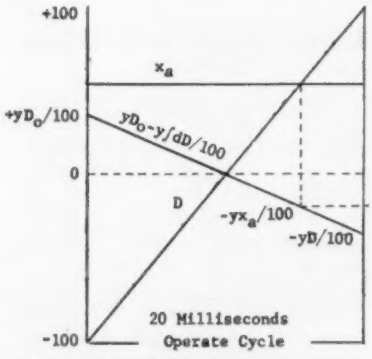


FIG. 4. COINCIDENCE of ramp D with X_a.

is much greater than the frequency at which x_a is varying.

Multiplication and division with DYSTAC are accomplished in much the same way. The difference between the two is in the arrangement of inputs. The variable y is fed to the comparator when dividing and to the memory circuit when multiplying. In either computation the B_D potentiometers are set to identical values.

Using the same principle of converting a variable normally generated in an analog computer as a function of time to a function of another computer variable, the author showed how is was possible to generate all the other non-linearities he mentioned in his introduction, and concluded that:

"The basic principles described and used with each application can be used for many additional applications. Of particular importance is the fact that any function able to be expressed as a differential equation can be generated by the methods outlined. These examples go beyond "filling a need" for non-linear generation by suggesting methods of approach to problem solutions heretofore impractical for serious consideration."

Nelson and Fried on Bounded Fourier Integrals

The next paper, "Solutions of Bounded Fourier Integrals on the Dystac® Computer," by **Joe M. Nelson** and **Stanley Fried** (both of Computer Systems Inc.) was abstracted by the authors as follows:

"The evaluation of bounded Fourier integrals with parameter variation is extremely laborious by conventional computer techniques. The study of the parametric variation of a microwave antenna design has been used as one example of a new computer technique for accomplishing this quickly. The use of DYSTAC® and Repetitive Operations technique

DR. J. H. MOSER has Ph. D., 1954, Oregon State College, in Analytical and Physical Chemistry. He was with Shell Oil and Shell Development until 1959, is now Sr. Research Chemist with Houston Research Laboratory.

yields rapid automatic evaluation of bounded Fourier integrals at closely spaced discrete values of the parameter."

Moser, Reed and Sellars on Non-Linear Programming

The authors' abstract of the third paper, "A Non-linear Programming Technique for Analog Computation" by **J. H. Moser, C. O. Reed,** and **H. L. Sellars,** all of Shell Oil Co., Houston Research Laboratory, Houston, Texas, states:

"In using an analog computer for repetitive solution of a set of differential equations representing a system, additional circuitry may be concomitantly employed to automatically change the value of independent variables so that maximization or minimization of a given objective function may be achieved. Functional constraints as well as bounds on the variable also can be imposed on the optima. One can start the problem from an infeasible region of the variable space as well as from a feasible region.

"The procedure uses (1) finite differences to approximate the partial derivatives of the objective function (gradient elements), (2) high-speed electronic switching for logical operations, and (3) dynamic memory devices."

The example process chosen was of naptha reforming, with two adiabatic reactors in series. Referring to Fig. 5, a low octane-number, low aromatic-content feed-stock is passed through the system shown (recycle is not considered). The effluent gasoline will be of higher octane-number than the feed, the magnitude of which depends on the independent process variables. Referring to Fig. 6, the problem will be taken to be: What is the best value of total "residence time" (L_B) and inlet temperature (T_O) to the reactors to maximize "profit" while producing gasoline with an octane number at least equal to a given value?

The authors show how the example problem can be solved, and conclude:

"It appears that the technique described can be employed profitably in both design and operation studies for the optimization of a wide variety of chemical processes, and can, in principle, be used with any number of independent variables.

"The technique is generally not too feasible for complete implementation of digital computers, due to the time generally required for each solution of the 'process simulator'—especially if relatively large systems of highly non-linear differential equations are involved. On the other hand, if the process simulator is being repetitively solved on an analog computer at a rate of, say, 50 per second, 3000 steps would be made in a minute, so it seems that several minutes should suffice to obtain an optimum."

Baldridge and Van Wagoner on Process Control System Design

The final paper of the day was "The Application of Repetitive Operation and Dynamic Storage to Industrial Process Control System Design" by **Bruce H. Baldridge** and **Gerritt Van Wagoner** (Daystrom Inc., Control Systems Div., La Jolla, Calif.).

The Control Systems Division of Daystrom, Inc. is engaged in Systems Engineering for industrial plants, leading to complete process automation. This work involves the design, manufacture, and installation of solid-state analog control systems and on-line digital computers.

Due to the size and complexity of the processes to which Daystrom systems are applied, and the advanced concepts of automation employed, it became apparent that the design and evaluation of these systems should take place as much as possible in the plant in La Jolla, California rather than in the field. In order to evaluate properly the functional requirements of a system, an accurate dynamic model of the process for which it is being designed is needed. The logical design tool for this simulation is an analog computer.

The immediate problem with which Daystrom was faced was the complete automation of a steam-electric generating plant, the Little Gypsy Station of the Louisiana Power and Light Co. Daystrom is furnishing a hybrid system composed of a central on-line digital computer plus all of the major analog control systems for combustion control, feedwater control, and steam-temperature control of the boiler. This automation system is charged with the responsibility of automatically starting up the plant (which invloves over one million sequential operations), shutting it down, and operating it in the most efficient way possible.

The analog control equipment was designed with the recognition that complex cross-coupling exists in a power plant, and the transfer functions involved change considerably with load. In order to control the system in an optimum fashion, the controls had to be "adaptive" and "non-

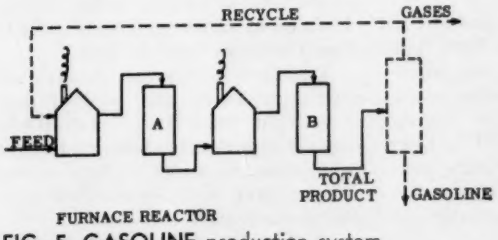


FIG. 5. GASOLINE production system.

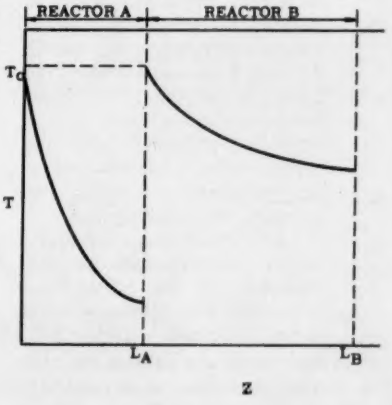


FIG. 6. PROFIT depends on residence time.

interacting." These requirements suggested strongly that the use of an analog computer was almost mandatory in the design and check-out stages of the equipment development.

Besides the manipulation of the set points of the analog controls for optimization and the adjustment of the control parameters to achieve adaptive control, the Daystrom digital computer will be monitoring the performance of the analog control systems and is designed to step in and take over control if any malfunction is detected. This digital computer control back-up of the analog controls is an important means by which Daystrom obtained the utmost in system reliability. The application of direct digital control to a complex power plant for the first time definitely warranted the use of the most advanced simulation equipment available.

The solution of the problem took the following route:

1. Extensive transient tests were run on a power plant similar in design to Little Gypsy.
2. Slight differences in design between the two plants were taken into account analytically in order to modify the response curves with the aid of Rep-Op.
3. Power-plant transfer functions were derived and adjusted to match the modified test results, using repetitive operations.
4. The resulting power-plant simulation was programmed in compressed time on the real-time analog computer.
5. The analog control systems also were simulated in compressed time on the Computer Systems, Inc. computer, and evaluated.
6. The actual Daystrom analog control equipment was connected to the simulation in place of the simulated controls, thoroughly tested, and shipped.
7. DYSTAC® was employed on the Computer Systems, Inc. computer to simulate the digital control computer by which the digital control program, including the minimum sampling frequencies, were determined.
8. The DYSTAC® simulation of the digital control computer was replaced with the actual Daystrom digital computer and the design programs were verified.

In their paper the authors describe in some detail the rep-op and dynamic memory computer mechanization of the foregoing steps, and conclude:

"The examples given of the uses of repetitive operation and DYSTAC® in the design of hybrid analog-digital control systems just scratch the surface of the possible applications of these techniques in this field. Future uses of this equipment will extend into the solution of the partial differential equations of the process itself, as well as more extensive digital program simulation. Daystrom believes that the inclusion of these features in an analog-computer facility used in the areas of analog and digital process control system design results in a very powerful tool for the control engineer."

Jury on Partials

Although the last paper on the program, "A New Analog Computer Technique in the Solution of Partial Differential Equations" by **Stanley H. Jury** (University of Tennessee, Knoxville) was not presented, we give you herewith the abstract, so that you can get an idea as to whether or not you'd like to write for a copy:

"Recent developments in the field of high-speed-memory analog computers inspire the application of this type computer to the solution of partial differential equations. A transient heat-conduction problem was investigated and a computer diagram was developed based on the differential-finite difference equivalent of the transient conduction equation. The computer diagram includes an automatic continuous function generator, the principle of operation of which depends on the Newton Forward Interpolation Formula and its derivations."

Information (Without Theory)

We are in receipt of Volume IV, No. 11, of both *Computer News* and *Computer Abstracts*. Both are publications of Technical Information Company Ltd, Chancery House, Chancery Lane, London WC2, England. These are indeed first-rate publications: Abstract #2268 covers the *Simulation Council Newsletter* of September 1960!

DR. STANLEY H. JURY, Ph. D., U. of Cincinnati, has been teaching Chem. Eng. at U. of Tennessee and Oak Ridge Institute of Nuclear Study for 11 years. Has also consulted for Wright-Patterson, ORNL, and Computer Systems, Inc.

SCI Activities

So far 231 applications for membership with first year's dues ($3, which includes the *Newsletter* inside *I&CS*) have been received by your SCI Secretary. We need 400 members to be eligible for membership in the American Federation of Information Processing Societies. So, in the words of Jack Sherman, "Let's all dig in and put our shoulders to the wheel and our nose to the grindstone. This will assure that you will get muddy feet, a sore shoulder and a skinned nose, but at least everyone will know you've tried."

By now we hope your Council Chairman or Secretary has told you about the plans devised by the SCI Executive Committee for improving your *Newsletter*. Success of the planned improvements depends largely on the response of individual Councils, speakers, and members. Only in this way can we keep it truly *your Newsletter*.

Newsletter Material Received —to be reported

Western Simulation Council Meeting of 11/10/60

Hans Meissinger, Chairman of the WSC Steering Committee, has succeeded in obtaining summaries of two of the five talks given at the 10 November meeting at the Norair Division of Northrop Aircraft, where **Lee Ohlinger** was our host.

Leo Yoskowitz has sent us an outline of his remarks on "Pre- and Post-flight Simulation," and **Richard Wolpert** forwarded an abstract of "Automatic Computer Applications to Northrop T-38 Inertia-Roll Coupling Analysis."

Nothing more on that meeting.

Guess the other three speakers got stage fright—or regretted what they said.

Southeastern Simulation Council Meeting of 11/11/60

Thanks to **Jim Tootle,** Secretary of the Southeastern SC, we have information on three of the four papers given at their meeting at Arnold Engineering Development Center in Tullahoma, Tennessee. Hopefully we'll get more info on this meeting in the near future.

Western Simulation Council Meeting of 1/12/61

Your Ed is happy to report that **Harry Harmon** and **Wilbur Steger** have responded to his request for a Reader's Digest type of condensation of their presentations at the January 12th meeting at Systems Development Corporation in Santa Monica.

Mr. Harmon gave us a broad-brush treatment of SDC's activities, and Mr. Steger told us about "Manned Simulation and the Design and Operation of Complex Military Systems." You'll be reading about these things—and others, if the other speakers will help me remember and translate what they said.

Programs Announced

Eastern Simulation Council; 20 February 1961; IBM Command Control Center, Federal Systems Division, Kingston, New York.

Subject: "Simulation in a Digital Computer Company"

"Simulation of a High-Performance Hydraulic Positioning System"—**R. P. Auyang** and **G. N. Tsilibes**

"Circuit Simulation by a Direct Approach" by **C. T. Lecher**

"Computational Machine Analysis of the Transient Response of Non-Linear Circuits" by **P. A. Honkanen**

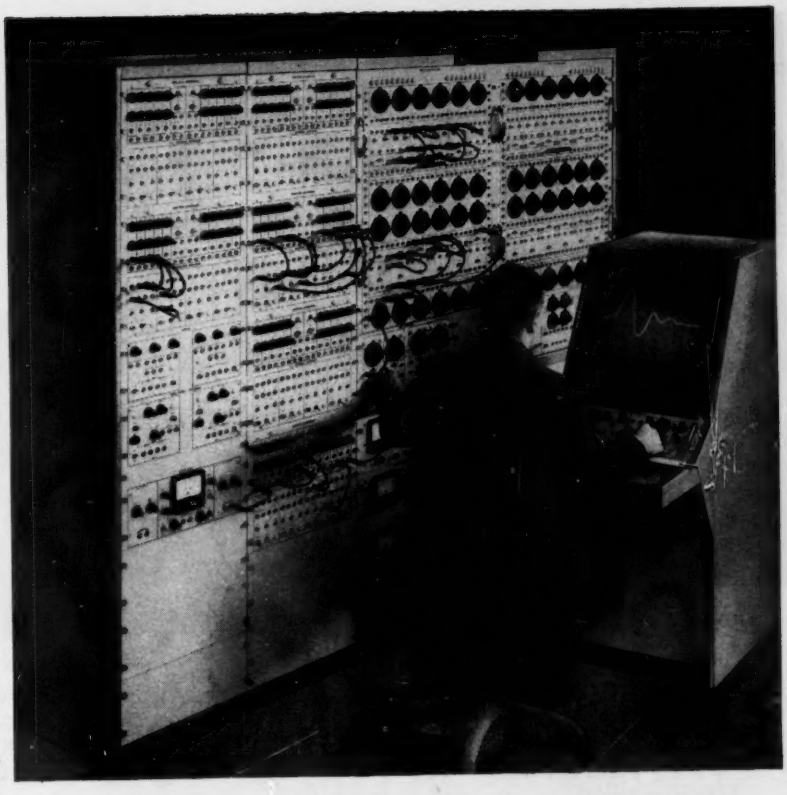
"Simulation for Display System Design" by **W. E. Smith**

"Iteration Procedures for Parametric Model Building" by **W. Brunner**

Western and Rocky Mountain Simulation Councils; 10 March 1961; University of Arizona, Tucson. Subject:

"Statistical Techniques in Simulation" and "The Role of Analog Computers in Engineering Education"

Speakers: Dr. Granino A. Korn (University of Arizona)
Mr. John Wait
Dr. Wallace Vander Velde (MIT)



THE ONLY AVAILABLE
STATISTICAL-ANALOG COMPUTER

The GPS Statistical-Analog Computer is without a doubt the most advanced in the state of the art, and is in every sense of the meaning . . .

- A TRULY HIGH-SPEED, HIGH CONFIDENCE-LEVEL COMPUTER
- A TREMENDOUS TIME AND MANPOWER SAVER*
- UNRIVALLED OR UNEQUALLED IN PERFORMANCE
- VERSATILE IN APPLICATION

The basic GPS computer is a compressed time-scale analog computer which operates 3000 times faster than real time. A solution is generated and repeated automatically at rates up to 50 times/sec. As many as 3000 independent runs or solutions can be statistically evaluated in a minute of time.

With the GPS computer you eliminate the drudgery of routine analyses, the endless footage of data recording, and the subsequent tedious data reduction.

Because of the new design principle and inherent versatility, the GPS computer provides immediate computation of the statistical and dynamic characteristics of:

- *Missile guidance and control systems*
- *Radar systems in general*
- *Process and quality control*
- *Flight control*

*An analysis of a missile miss-distance was conducted at the GPS COMPUTER CENTER by the research laboratory of a large aircraft firm. Their report stated that, "25 times as much data (with higher confidence-level) was collected in one week on the GPS computer as was collected and analyzed in 4 months time on a slow-speed computer"

Our engineers are ready to assist you.
For further details please write or call Dept 21

GPS INSTRUMENT CO., Inc.

180 NEEDHAM STREET • NEWTON 64, MASS.

CIRCLE 93 ON READER-SERVICE CARD

Model 6190

...Makes time with Atomic Accuracy

Solid State EW Timing Code Generator Uses Atomchron Input

Epsco-West's new Model 6190 Time Code Generator is accurate, flexible, and reliable. In conformance with recommendations of the Interrange Instrument Group (IRIG), the Model 6190 generates a 36 bit 100 pps code, a 28 bit 2 pps code and a 20 bit 1 ppm code. Other outputs are available to drive digital printers, digital tape recorders, strip-chart recorders, oscillograph galvanometers, synchronizing signals and mixed tones of precision frequencies.

The EW Model 6190 is one of a complete line of solid state, modular time code equipment which includes time code generators, time code translators, timing terminals, and universal tape search equipment.

Complete technical information on the Model 6190 Time Code Generator is ready now. Call your nearby knowledgeable Epsco-West engineering representative or address Dept. 54.

Advanced Circuitry Stems From Transistor Know-How

In the Model 6190, all pulse widths and timing are directly derived from the digital dividers and time accumulator by diode matrices. No one-shot circuits are used. Information is not transferred from one register to another. No "stub" counter chains are used. These design features provide absolute synchronism and minimum distortion. Modulation occurs precisely at the true positive going zero-axis point on the carrier.

Epsco-West Inc.

A Subsidiary of EPSCO Inc., Cambridge, Mass.

240 E. PALAIS ROAD • ANAHEIM, CALIFORNIA

7

KEY SPECIFICATIONS

Input Signal

100 kc, 1-volt RMS, to impedance of 10,000 ohms. An internal frequency standard may be supplied as optional equipment.

Outputs

1. Logic Output, 36-bit parallel BCD (—12v for binary "zero", 0-volts for binary "one").
2. 20-bit, 1 ppm on 100 cps carrier, 1 hour time frame.
3. 28-bit, 2 pps on 100 cps carrier, 1 minute time frame.
4. 36-bit, 100 pps on 1000 cps carrier, 1 second time frame.
5. Three outputs of the 100 pps, 2 pps and 1 ppm modulation pulses at 2 milliampere max. for driving galvanometers.
6. Relay closure at 1 ppm, 28-bit, 2 pps code, closure for pulse durations.
7. 1 pps at 1-volt, synch pulse, accessible front and rear.
8. 1 pps relay closure of 200 ms.
9. Mixed tones output; 100kc, 50kc, 25kc, 12.5kc, 6.25kc, 3.125kc sine waves.

Elapsed-Time Range

399 days 23 hr. 59 min. 59 sec.

Accuracy

Dependent only on reference oscillator.

Size

19" wide by 10½" high x 18" deep.

CIRCLE 94 ON READER-SERVICE CARD

Recording of Intervals on a Multi-Pen Recorder

EDWARD B. YONTEF
HERBERT M. JENKINS

Bell Telephone Laboratories, Incorporated

IT often is desirable in psychological experiments to make pen recordings showing when each of several events occur (e.g., stimuli, responses, reinforcements), and the duration of an event or latency (e.g., the interval between the onset of a stimulus and the response).

Operations recorders (Fig. 1) with event-marking pens are suitable for this purpose. However, a problem in recording arises when the experiment runs over a long period because if the time durations to be recorded and measured accurately are on the order of seconds, a high chart speed is needed. When the experiment runs for several hours, this results in long paper records which are expensive and inconvenient to handle. The problem is to achieve sufficient resolution without using high chart speeds.

The method described here records time durations in a digital form that can be read accurately and quickly. Consecutive intervals of time are marked *across* the chart. Each mark *along* the chart represents 10 time-intervals, or one decade. Thus time has been compressed by a factor of 10 along the chart, and the chart speed can be reduced by a factor of 10 (compared to a standard chain of pulse "pips" made by a single pen), with no loss in resolution.

A block diagram of the recording system is shown in Fig. 2. If a single pulse from a timing pulse (0.1 second) train is fed to a recording pen, it causes a momentary deflection. If the following pulse* is then fed to an adjacent pen, and so on, a staircase sweep of markings along the horizontal axis can be generated. The total number of marks provides a time measure; the frequency (rate of marking) determines the time resolution.

The chart speed only needs to be sufficient to allow the *start* of a decade of marks to be distinct from the preceding decade. A chart speed which suits this purpose for 0.1 second pulses is 3 inches per minute. A tracing of a record is shown in Fig. 3.

*Keister, Ritchie and Washburn, *The Design of Switching Circuits*, p. 255, Fig. 11, 12, Van Nostrand, New York, 1951.

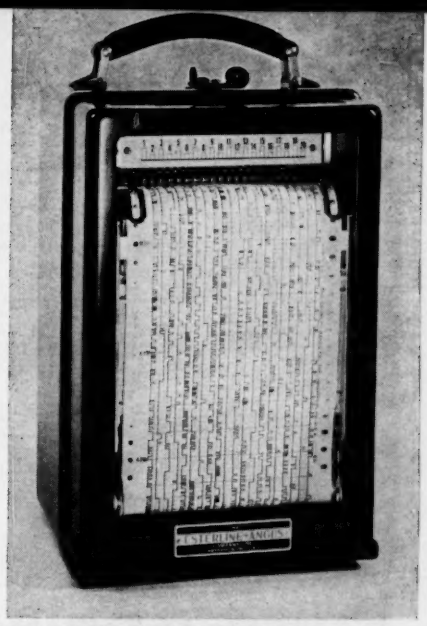


FIG. 1. OPERATIONS RECORDER used in study has 20 event-marking pens. (Photo courtesy Esterline-Angus Co., Inc.).

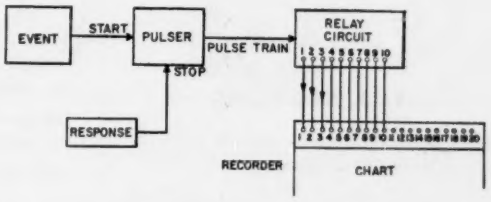


FIG. 2. UPON STIMULUS of the subject, the event box starts the pulse generator. The first time pulse operates pen 1, the second pulse is directed to pen 2, the third pulse to pen 3, etc., by the relay counting circuit. The response pulse stops the pulse generator. Western Electric 291A Mercury Relay can operate at speeds to 50 pulses per second.

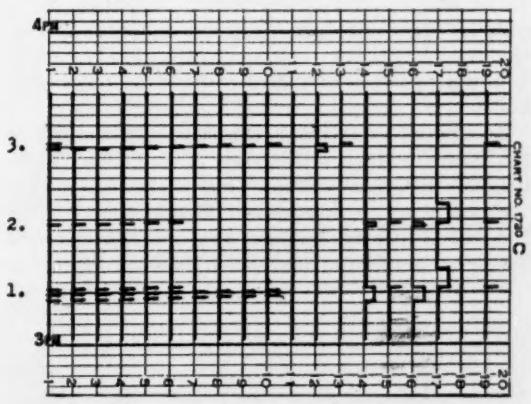


FIG. 3. PENS 1 to 10 display the time measure. User need only count the marks made by pen 10 (2 in example 1) to count seconds. Then the last pen operated in the incomplete decade gives tenths of a second. (2.6 in example 1). Example 2 shows a reading of 0.6 second. Example 3 shows 1.1 seconds. Pens 12 to 20 are used to record stimulus values, responses, and reinforcements.

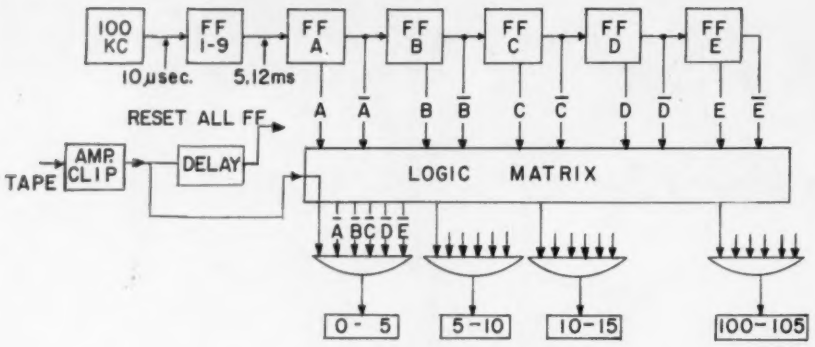


FIG. 1. FLIP-FLOPS A to E develop logic signals for "time basket." Any pulse interval between 0 and 5 ms is counted in first counter, 5-10 ms in second counter, etc.

Pulse Analysis by Histogram

V. J. CAGGIANO

Applied Physics Laboratory
The Johns Hopkins University

In neurological work it is necessary to obtain histograms—frequency distribution of pulse signals in nerves. This is done by measuring the interval between the pulses, and counting the number of pulses separated by any given interval.

NEUROLOGICAL studies conducted by the Central Laboratory Machines group of the Applied Physics Laboratory in conjunction with Walter Reed Medical Institute include recording on magnetic tape the electrical output of nerve cells of cats, with various forms of stimuli. The electrical outputs of these nerve cells usually appear as irregularly-spaced pulses of constant amplitude and width (Fig. 2).

At present there are two viewpoints concerning the form in which intelligence is contained in the neuron's electrical output. One viewpoint is that the pulses are in the form of a code contained in the pulse *spacing* because the other parameters (such as amplitude and pulse width) appear to be fixed. The pulse-coding hypothesis is largely accepted at the Applied Physics Laboratory (but not by the writer) and, therefore, there is a need for decoding techniques in order to pursue this hypothesis.

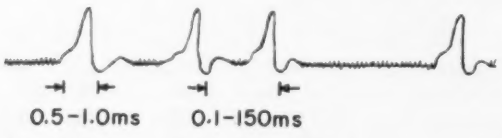


FIG. 2. NERVE-CELL IMPULSES are irregularly spaced pulses of fairly constant amplitude and width. Pulse duration is from 0.5 to 1 ms; interval between pulses is from 0.1 to 150 ms.

Frequency Distribution of Pulses

One method analyzes spacing between any two consecutive pulses. A plot of the number of times an interval occurs (that is, the number of pulses with given spacing) versus pulse spacing results in a *histogram.* (Another decoding technique being investigated at the present time is an *autocorrelator.*) If the assumed hypothesis is valid, and if the information content can be related to pulse spacing, an entirely new type of code may evolve. This could possibly change known transmission techniques, digital computer operations, or open doors to a new type of mathematics.

The method used to obtain the histogram uses only a few basic circuits—primarily flip-flops and AND gates. The flip-flops are used to establish a set of 5-millisecond time intervals (or "time baskets"). The intervals are 0-5 ms, 5-10 ms, 10-15 ms, etc. (Figs. 1 and 3). Each time-basket drives a separate counter. The 0-5 ms counter shows the number of pulses that arrived less than 5 ms after a preced-

ing pulse. The 5-10 ms counter reads out the number of times that the interval between pulses was 5 to 10 ms, etc.

Circuitry

The basic circuit is the "time basket"—a timing circuit that develops successive intervals—0-5 ms, 5-10 ms, 10-15 ms, etc.

This is done by enabling a gate with five signals from a series of five flip-flops (A-E in Fig. 1). The A signals are from flip-flop A, the B signals from B, the C signals from C, etc.

If the input to flip-flop A is a series of 5-ms pulses, then the output of A is a series of 5-ms square waves, as shown in Fig. 3. The output of flip-flop B is then a 10-ms square wave, the output of C is a 20-ms square wave, D produces a 40-ms square wave, and E an 80-ms square wave.

If we define the truth statement as a positive-level signal—that is, A exists when the A line is positive, $\overline{A}$ exists when the $\overline{A}$ line is positive, etc., we see that in the interval from 0-5 ms, the positive signals from the flip flops are on lines $\overline{A}$, $\overline{B}$, $\overline{C}$, $\overline{D}$, $\overline{E}$. In the interval 45-50 ms, the positive signals are A, $\overline{B}$, $\overline{C}$, D, $\overline{E}$. As there is only one combination of signals for every 5-ms interval, a gate can be enabled by these signals to produce the "time basket."

This is shown in Fig. 4. By enabling each gate with the proper set of five flip-flop signals, each gate is enabled for one 5-ms interval, successively.

If a pulse arrives in any given interval, it completes the number of input signals needed to trigger that gate which has been enabled; the gate actuates the appropriate counter. Thus the nerve pulse is brought to all gates, but actuates only that one which has been enabled.

As every pulse resets the flip-flops, the count begins with every pulse, and ends when the next pulse is sorted into its proper time bin, at which time the process repeats.

As a 100-kc oscillator was available, a series of nine flip-flops divide the 100-kc signal by 2^9 (512). The result is a 5.12-millisecond-duration output (10 microseconds times 512 equal 5120 usec, or 5.12 ms).

The 32 AND gates could be connected simultaneously, and a complete histogram obtained by playing the tape through only once. However, to save counters and gates, the logical selection of variables was done by two pre-wired switches, which enables selection of any two time intervals simultaneously. With only two AND gates, it was necessary to play the tape over ten times in order to get all 20 categories. The only reason for this arrangement is a temporary lack of components.

As tapes are inherently noisy (sometimes as bad as 2:1 signal-to-noise ratio) a clipper was designed which passes only the peaks of the signals. The clipper was made a part of a pulse standardizer; the combination can receive positive or negative inputs and always gives out standard positive pulses. The standardized pulse is 15 volts, adjustable from 0.5 to 2.5 milliseconds.

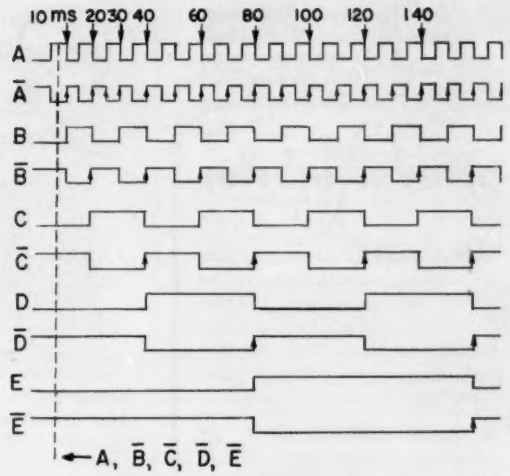


FIG. 3. SIGNALS FROM FLIP-FLOPS A to E. In any one 5-ms interval, there is a unique set of signals. In 5-10-ms interval the positive signals are on lines A, $\overline{B}$, $\overline{C}$, $\overline{D}$, $\overline{E}$.

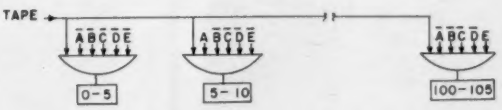


FIG. 4. FIVE SIGNALS from a set of five flip-flops establish a series of "time baskets." For example, first gate (with inputs $\overline{A}$, $\overline{B}$, $\overline{C}$, $\overline{D}$, $\overline{E}$,) is open for 0-5 ms. If signal from tape arrives in this interval, it is counted in Counter 1. Second gate is open only during interval 5-10 ms, etc.

All circuits (except bias supply) are transistorized and constructed on 4" x 5" plug-in cards. The complete sorter is housed behind a 19" panel, 9" high and 9" deep, except for power supply. The pulse amplifiers provide a convenient way of obtaining a small delay between counting a pulse and resetting the flip-flops. This delay insures that the flip-flops will not be reset during or before the time the input pulse is used to trigger the AND gates. The pulse used internally in the sorter is 2.5 microseconds wide and 10 volts high. Although only a 2.5-microsecond delay is required, a 5-microsecond delay is used to insure reliability.

Many variations are possible. For example, if the output of the AND gate is connected to a recorder, then a time variation of pulse density also would be obtained.

The advantage of making histograms using this sorter technique over reducing the data manually is in the time saved—30 to 1 for short records. Histograms also can be made from longer records (20,000-30,000 pulses), which was virtually impossible previously. Furthermore, no technical skill is required.

This work was supported by the Bureau of Naval Weapons, Dept. of the Navy, Contract NOrd 7386.

Stewart Ashton, our Chief Engineer, reports on the all-new . . .

pHayes-master (TM)

HERE AT LAST is a simple, compact, space-saving package that provides *microsecond* response for controlling power to electric furnaces . . . and *for numerous other applications* and processes where temperatures must be precisely regulated.

A TRANSISTORIZED UNIT, the new Hayes pHayes-master now replaces costly and bulky saturable core reactors, tubes, magamps, powerstats, etc. — with *one,* small, smartly-designed control unit!

VERSATILE, TOO . . . pHayes-master can be used with most proportioning type temperature instruments . . . handles up to 70 amp. capacities at 220 volts, with stepless control over the full 0-100% range. Highly accurate, pHayes-master provides instantaneous, straight-line response . . . completely without lag or hunting.

ECONOMY is another big advantage. The Hayes pHayes-master features a high power factor—expends only a fraction of the power source for control. Simple rugged construction and circuitry make it far easier and cheaper to install and maintain than conventional control devices.

These are just the highlights. If *your* equipment or process calls for close control of power for heat generation, get the *complete* facts on the all-new Hayes pHayes-master. Write for new Bulletin C-1,or tell us about your application requirements. — C.I.HAYES, INC., 944 Wellington Ave., Cranston 10, R. I.

C. I. HAYES, INC.

Established 1905

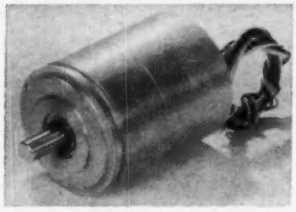
ELECTRIC FURNACES

It Pays To See Hayes for metallurgical guidance, lab facilities, furnaces, atmosphere generators, gas and liquid dryers, pHayes-master (TM) control units.

CIRCLE 95 ON READER-SERVICE CARD

ICS NEW INSTRUMENTS

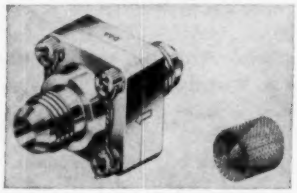
DIGITAL SHAFT ENCODER



New 1½"-dia Type VS-256E Vernisyn gives resolutions, as required, of one part in 2^{14}, 2^{15}, and 2^{16} in single turn. Output is in form of alternate fine and coarse pulse trains on separate lines to provide complete angular position answer with respect to reference radius into 14 to 16 stage binary counter every 40 msec. Accuracy maintained up to slew rates of 1 to 4 min/sec without time correction.—*Data Tech,* 238 *Main St., Cambridge* 42, *Mass.*

CIRCLE 211 ON READER-SERVICE CARD

FILTER ASSEMBLY



New 1⅛" x 1⅛" x 2" Filter Assembly for fluid line systems has been in service with gases to 2250 psi, withstands temps from −350° to 500°F. Fits ¼" and ⅜" tube sizes. Cylindrical, wire-mesh element provides 1.2-in² filter surface; approx ½ is open flow area.—*Dumont Engineering Corp.,* 1401 *Freeman Ave., Long Beach, Calif.*

CIRCLE 212 ON READER-SERVICE CARD

DIGITAL VOLTMETER

New Series 5000 Transistorized Digital Voltmeter uses solid-state computer type amplifiers to achieve high input impedance independent of null, prevents excessive loading of critical circuits when instrument probe is first applied. Provides 200 readings/sec (average), with ±0.01% accuracy; brilliant readout display; decimal and binary-coded-decimal electrical outputs.—*Electronic Associates, Inc., Long Branch, N. J.*

CIRCLE 213 ON READER-SERVICE CARD

THIN-WALL BRASS TUBING

New small-diameter seamless drawn brass tubing has precision tolerances of diameter, wall, out-of-round, camber, and length exceeding ASTM minima. Walls from 0.005" to 0.030"; OD's 0.050" to 0.500"; round, elliptical, tear-drop, polygonal, polygonal outside and round inside, and special shapes.—*Avins Industrial Products Corp.,* 50 *Broadway, New York* 4, *N. Y.*

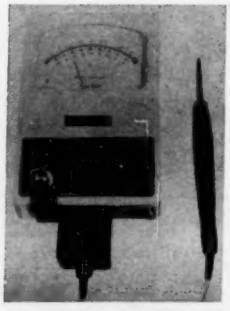
CIRCLE 214 ON READER-SERVICE CARD

DIFF DC AMPLIFIER

New Model 516A wide-band differential d-c Amplifier features three different plug-in front ends, making basic unit three amplifiers in one. Frequency response to 40 kc, output impedance less than 0.05 ohm, drift less than 4 μv, common mode rejection 120 db.—*Allegany Instrument Co., Div. Textron Electronics, Inc.,* 1091 *Wills Mountain, Cumberland, Md.*

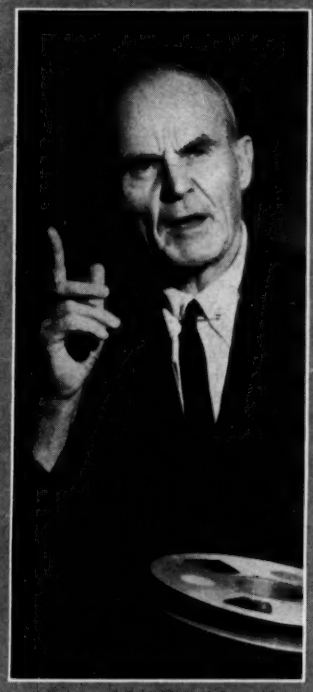
CIRCLE 215 ON READER-SERVICE CARD

TEMP TEST INSTRUMENT



New glass-tipped 0.012"-dia probe containing stabilized thermistor is used with standard A+ Thermophil instruments to read temps of electronic components within 0.2F°. Locates improperly functioning components and chassis hot spots, does not short out equipment. Readings between −154° and 554°F, 3 and 4 scales for various temp spans. Probes vary in length, shape, mounting, all calibrated and interchangeable. Bulletin IGVO.—*Atkins Technical Inc.,* 1276 *W.* 3 *St., Cleveland* 13, *Ohio*

CIRCLE 216 ON READER-SERVICE CARD



New equipment without capital outlay

...from Ampex

Ampex data recorders on the newly announced lease program can help you in two ways. Leasing lets you pay for the use of your data recorder only as you need it.

Through installment purchases, you are investing in your Ampex data recorder while it works for you.

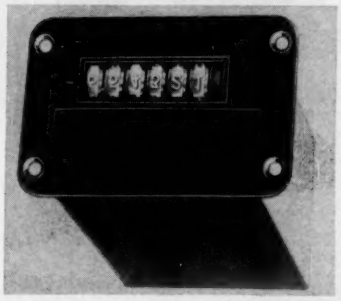
Either way, pressure on your working capital is reduced to the minimum. Complete program details and equipment specifications from:

AMPEX

AMPEX INSTRUMENTATION PRODUCTS CO.
Box 5000 Redwood City, California

CIRCLE 96 ON READER-SERVICE CARD

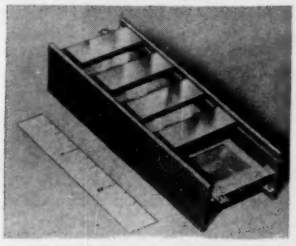
PRINTING COUNTERS



New high-speed Printing Counters with electrical reset to zero are available in add and/or subtract models with maximum counting rates from 1500 to 3000 pulses/min. Companion indicating units also available. Optional coil voltages from 12-230 v ac or dc.—*A. J. Baranoff & Associates, 1214 Park Lane, Santa Ana, Calif.*

CIRCLE 217 ON READER-SERVICE CARD

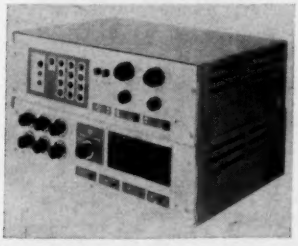
ULTRAVIOLET DETECTOR



New Model M-306 Electron Multiplier detects vacuum ultraviolet photons, soft X-rays and charged particles. Produces current gain in excess of 10^7 with applied potential of 2000 v. Power dissipation less than 0.1 w. Operates well in kinetic vacuum, can be exposed to air for indefinite period.—*Bendix Corp., Research Laboratories Div., Northwestern & 10½ Mile Rd., Southfield (Detroit), Mich.*

CIRCLE 218 ON READER-SERVICE CARD

AN-DIG CONVERTER

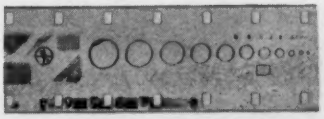


New analog-to-digital converter, Decimal Converter Model F, operates with equipment having max output resistance of 5000 ohms. Basic circuit is resistance bridge that senses position of input potentiometer and converts it to decimal form. Input resistance potentiometers form one arm of bridge; coded decimal resistances form balancing arm.—*Benson-Lehner Corp., 11930 Olympic Blvd., Santa Monica, Calif.*

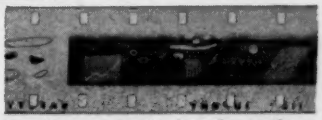
CIRCLE 219 ON READER-SERVICE CARD

NARROW-CHANNEL PHOTOGRAPHY

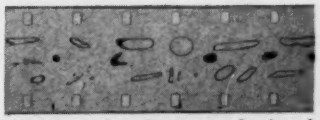
For people with the problem of photographing the interior of long, narrow channels, Kollmorgen has developed unusual devices capable of recording on film channels as narrow as 1/32 of an inch.



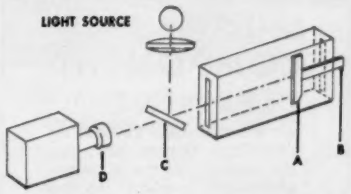
Above, actual size, is a test film of circles and numerals placed within a 1/32"-wide channel.



Above is a *panoramic* view of a continuous section of the same film . . . with marks enlarged 8x.



Pitting, corrosion, fracture and other defects of interior walls can be continuously recorded with full-dimensional accuracy . . . of exceptional value in quality control operations.



The secret of our insight: A highly precise 45° mirror (A), mounted on a reed (B), is inserted in one end of the channel. A beam splitter (C) directs a powerful light into the channel from the opposite end which is reflected by the mirror onto the sidewall. The photographic leg of the system receives the image from the channel mirror and through the beam splitter. A camera objective (D) focuses the image on the film. The channel is advanced by a carriage in precise synchronization with the advance of film. Result: a continuous, clear photographic record of the entire channel.

Various modifications of this device have been applied to channels up to six feet long. For longer and wider channels we have designed a miniature self-propelled camera, mirror and light source capable of presenting a continuous image on film with resolution sufficient to reveal scratches and hair-line cracks smaller than .010 inch.

If you need special insight on "inaccessible" interiors, or information on other unusual applications of optics/electronics/mechanics—let's talk it over.

Write Dept. 12-3

KOLLMORGEN CORPORATION
NORTHAMPTON, MASSACHUSETTS

CIRCLE 97 ON READER-SERVICE CARD

CIRCLE 98 ON READER-SERVICE CARD

MISSILE COMPONENT CLEANING

We are equipped to meet all technical requirements for the cleaning of metal, teflon and other products to the high cleanliness level needed for compatibility to liquid oxygen, helium or other exotic fuels.

Microscopically cleaned to 25 micron particle size

Complete military approved environmental facilities for

- Accelerometers
- Pressure Indicators
- Pressure Pilots
- Hand Valves — HP & LP
- Solenoid Switches
- Pressure Switches
- Gauges, all types
- Elbows, duct work, piping, stainless
- Flexible hoses from ½" to 10" diameter, length to 30', stainless steel, teflon, teflon lined
- Expansion joints, stainless steel
- Valves
- Regulators
- Tubing, fabricated, stainless steel

Rigid inspection, testing and complete packaging facilities with resident military inspectors.

Call or Write Dept. 3.

MISSILE COMPONENT CLEANING LABORATORIES

2224 N. 10th St., Phila. 33, Pa.
BAldwin 9-0400 TWX-PH 336

A division of the Quaker Export Pack Co.

CIRCLE 99 ON READER-SERVICE CARD

Ultra-fast Optics

for

INFRA-RED

Instrumentation

Reflective Optics

Cassegrain Systems

Paraboloids to f/.3

Off-axis mirrors

Refractive Optics

Si and Ge Optics

IR Windows

Aspherics

Mechanical Mountings

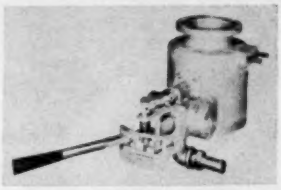
John Unertl Optical Co.

3551-55 East St.

Pittsburgh 14, Pa.

CIRCLE 100 ON READER-SERVICE CARD

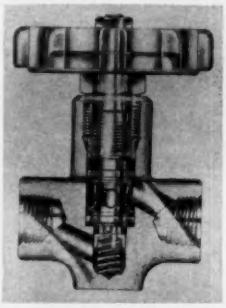
3-WAY VACUUM VALVE



New Model 94552 Three-Way Vacuum Valve for master control in high vacuum system using diffusion pump and mechanical fore pump replaces usual roughing, foreline, and high vacuum valves built into conventional systems, reduces down time, provides more positive switching action. Main valve throat openings 4" dia; roughing line passages equal to 1" pipe.—*Central Scientific, Div. Cenco Instruments Corp.*, 1700 *Irving Park Rd., Chicago* 13, *Ill.*

CIRCLE 220 ON READER-SERVICE CARD

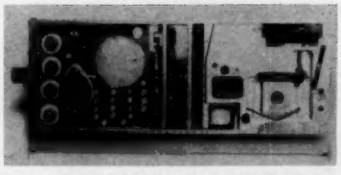
SHUTOFF VALVES



New 920-T Series Shutoff Valve is rated to 6000-psi operating pressure liquid or gas, is specifically intended for severe corrosive conditions. Features Teflon V packer seated against Belleville washer for dead-tight seal. Floating sleeve rises to protect V packers from fluid flow when valve is open.—*Circle Seal Products Co.*, 2181 *E. Foothill Blvd., Pasadena, Calif.*

CIRCLE 221 ON READER-SERVICE CARD

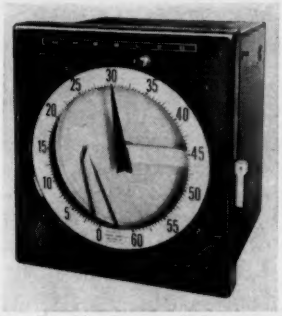
INFRARED RADIOMETER



New Model E-2D Infrared Radiometer (1½" x 3½" x 9", 3 lb) modulates incoming radiation with segmented chopping wheel, filters it to calcium fluoride lens which focuses onto lead sulfide detector. Detector output at fixed frequency of modulated radiation is amplified by low-noise, transistorized a-c circuit with synchronous rectification to minimize system noise, isolate source-radiation from spurious unmodulated energy.—*Block Associates, Inc.*, 385 *Putnam Ave., Cambridge* 39, *Mass.*

CIRCLE 222 ON READER-SERVICE CARD

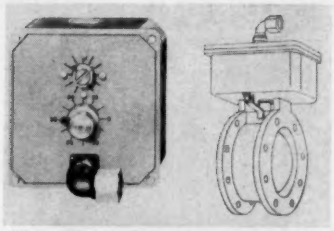
ROUND-CHART CONTROLLERS



New Double-O round-chart recording and indicating Controllers are self-contained, null-balancing instruments requiring only external sensor. Units record and control variables such as speed, strain, pH, etc. which can be resolved into electrical signals. Accurate to ½ of 1% for all scale spans in pyrometric range.—*Barber-Colman Co., Wheelco Industrial Instruments Div., Rockford, Ill.*

CIRCLE 223 ON READER-SERVICE CARD

BUTTERFLY VALVE OPERATOR



New Valve Operator for butterfly valves and dampers mounts directly on 1"-dia valve shaft, eliminates linkages or special brackets. Torque lug fixes position to valve body; limit switch externally adjusts over 90° stroke; provides 2-position or floating control operation.—*Automatic Timing & Controls, Inc., King of Prussia, Pa.*

CIRCLE 224 ON READER-SERVICE CARD

PULSE-GENERATING MODULE

Ten new models of A502 Pulse-Train Generating Modules are available in five pulse rate ranges (from 4-to-16 pps to 65-to-300 pps) and two temp ranges (−55° to +70°C and −55° to +125°C), operate on 28 ± 5 v dc (160 ma max). External adjustment provided on pulse rate; other output parameters match step-servo controller requirements.—*Automation Development Corp., 11824 W. Jefferson Blvd., Culver City, Calif.*

CIRCLE 225 ON READER-SERVICE CARD

CUT MAINTENANCE
ON PNEUMATIC INSTRUMENTS

WITH A

TRINITY

LOW COST

DRYER

Assure top reliability, long-life and performance from your pneumatic control instruments through a reliable, low-cost Trinity Heat-Les Dryer. Eliminate sludge, goo and other harmful elements from your instrument air, keeping your system clean as a whistle and permitting orifices, bellows, valves and other component parts to operate as they are intended for fast, positive and dependable response.

Trinity Heat-Les Dryers have proved themselves in many hundreds of installations. Among the many advantages they offer are...

● Low initial cost ● Low installation costs ● Low operating and maintenance costs ● No costly electric or steam heaters ● No increase in effluent air temperature ● Built-in safety system to supply dry air for extended periods after power failure.

AND UNITIZED DRY AIR SYSTEMS

Complete dry air systems including compressor, dryer, accumulator, instrumentation and necessary manifolding expertly engineered to provide an efficient source of dry air.

WRITE FOR COMPLETE DETAILS ON DRYERS AND SYSTEMS...

TRINITY World leader in dry gas/air systems

Heat-Les Dryers • Heat-reactivated Dryers
Thermocouples and Thermowells

TRINITY EQUIPMENT CORPORATION, CORTLAND, NEW YORK

CIRCLE 101 ON READER-SERVICE CARD

THE HP5 SERIES CYCL-FLEX FOR TIME CONTROL

Yes, our *New* Cycl-Flex Timer is as easy to adapt and change as a simple electric plug.

Don't let automation troubles get you down! . . . use our New Cycl-Flex for TIME CONTROL functions. Should your automatic controls fail for any reason, you can trace your trouble by plugging-in a spare timer. Movement of the TIME pointer indicates whether trouble is in the input or the output circuits.

Eagle's New Cycl-Flex Timer has been enthusiastically adapted by leading manufacturers of molding presses, dielectric heaters, machine tools and feed controls.

Write for Bulletin 125 or call your local Eagle Representative. He's listed in Sweet's Product Design File, Section 7d, or in Thomas Register.

SPECIFICATIONS • 10 sec. to 60 hr. dial • 2 instantaneous switches • 2 delayed switches • 12 terminals • Resets in 1/3 sec. • Mounts in 3 1/8" dia. hole

MANUFACTURERS OF THE MOST COMPLETE LINE OF INDUSTRIAL TIME-COUNT CONTROLS AVAILABLE

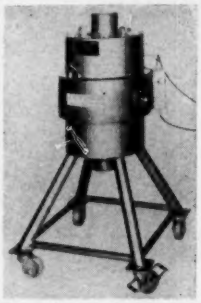
BLISS

EAGLE SIGNAL COMPANY • Moline, Illinois
INDUSTRIAL DIVISION

A DIVISION OF THE GAMEWELL COMPANY, AN E. W. BLISS COMPANY SUBSIDIARY

CIRCLE 9 ON READER-SERVICE CARD

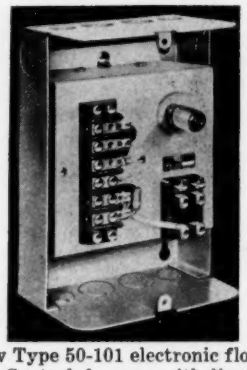
BERYLLIUM ANALYZER



New Beryllium Stream Analyzer continuously measures beryllium content (μg/liter) of solution or slurry with 10% accuracy in about 5 minutes. Detection based on production of neutrons by reaction of gamma rays with beryllium followed by indirect measurement of emitted neutrons. AEC-approved for use with 1-curie source in unrestricted area.—*Boulder Scientific Co., 250 Pearl St., Boulder, Col.*

CIRCLE 226 ON READER-SERVICE CARD

LEVEL CONTROL



New Type 50-101 electronic floatless Level Control for use with liquids of low specific resistance will not contaminate products. Low electrode potential of 9-v ac and electrode current less than 26 ma eliminate shock and sparking. Interchangeable terminal wiring for direct or inverse operation; sensitivity determined by value of fixed resistor mounted on terminal strip. Bulletin 334.—*B/W Controller Corp., 2200 E. Maple Rd., Birmingham, Mich.*

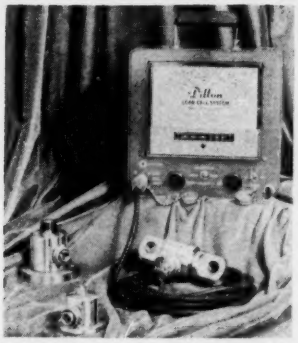
CIRCLE 227 ON READER-SERVICE CARD

MICRO THERMOCOUPLES

New HT Micro-Miniature Thermocouples (0.014" dia) for use in cryogenic temps to +3000°F are available with insulated, flattened, and exposed junctions. Response time of 13 msec with exposed junction. Data Sheet 4336.—*Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., 42 Fourth Ave., Waltham 54, Mass.*

CIRCLE 228 ON READER-SERVICE CARD

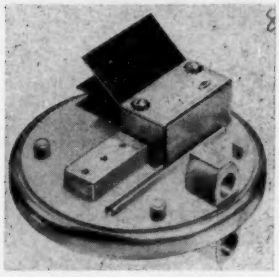
REMOTE READING LOAD CELL



New remote indicating Load Cell Systems in 27 capacities permit instantaneous direct readings of forces from 0-150 lb to 0-200,000 lb over 1000′ from cell. System uses differential transformer principle, eliminates usual tubes, amplifiers, circuitry. Accurate to within ½ of 1% of full capacity at any dial point, senses load changes of 1/10 of 1% of scale capacity.—*W. C. Dillon & Co., Inc.*, 14620 *Keswick St., Van Nuys, Calif.*

CIRCLE 229 ON READER-SERVICE CARD

DIFF PRESSURE SWITCH



New 1800 Series 4″-dia Switch operates from differential pressures as low as 0.15″ water with ranges to 80″ water; holds set point through various total pressures; operates from plus, minus or differential pressures in any position. Unaffected by severe vibration conditions, even near actuation point; no complicated linkages, bearing arrangements or sealing devices. Bulletin E-40.—*F. W. Dwyer Mfg. Co., Dept. IA-5, Box 373, Michigan City, Ind.*

CIRCLE 230 ON READER-SERVICE CARD

FLOW TRANSMITTER

New Chronoflo Bellows-Actuated Flow Transmitter for pressure-operated, explosion-proof remote flow metering in sewage plants or in pipe line distribution of gas, contains no mercury, withstands working pressures to 1000 psig. Rupture-proof bellows withstands overages equal to safe working pressures of housing without deformation. Time cycle of 8 sec, accuracy ±1% of span over range of from 10% to 100% of span. —*B-I-F Industries*, 345 *Harris Ave., Providence, R. I.*

CIRCLE 231 ON READER-SERVICE CARD

NEW! ELECTRONIC CONTROL METER

Patent Nos. 2,871,450 and 2,967,278

MODEL 2547

WITHOUT ELECTRICAL CONTACTS provides continuous output signal past selected control setting, with uninterrupted, accurate full-scale indication at all times. No electrical contacts at control point, so no control-point problems. No undesirable feedback because indicating and transistorized switching circuits are completely isolated. No pull-in or locking coils or special power supplies required. Available in two standard models with single or double independent control-arm circuits. Both may be had with scales for horizontal or vertical mounting, with zero at center, left or right.

FOR ACCURATE INDICATION AND CONTROL IN:

Communications
•
Missile Checkout
•
Nucleonics
•
Signal Monitoring
•
Voltage Control
•
Process Control
•
Data Processing
•
Alarm Systems
•
. . . or wherever dependable, fail-safe control is required

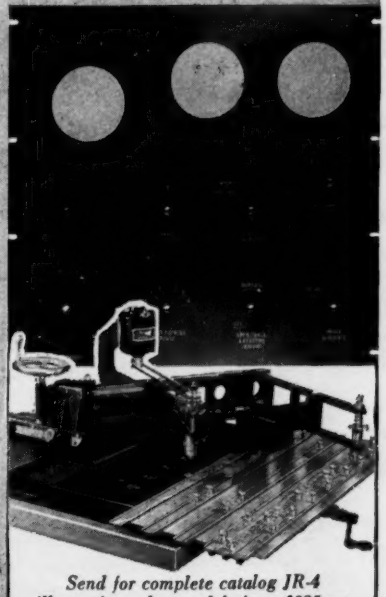
WRITE FOR ENGINEERING DATA SHEETS on our complete line of panel meters, side indicators, Electronic Control Meters, miniature multitesters.

miniaturization headquarters
international instruments inc.
P.O. Box 2954, New Haven 15, Conn., Cable: "INTERINST"

CIRCLE 103 ON READER-SERVICE CARD

any size panels

engraved in your own plant



Engrave 1-inch nameplates or 6-foot panels by unskilled labor.

Spindle covers 18¼″ x 6″ in one set-up — more than any other machine of its kind.

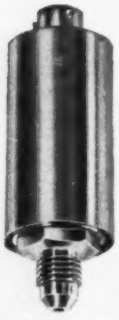
Bench type model I-R—$685.

Send for complete catalog IR-4 illustrating other models from $325 up

new hermes ENGRAVING MACHINE CORP.
154 WEST 14th STREET, NEW YORK 11, N. Y. IN CANADA: 359 St. James Street West, Montreal, P. Q.

CIRCLE 104 ON READER-SERVICE CARD

A Transducer Two Years Ahead of its Time



A completely new patented pressure sensor concept has been utilized in Servonic's new, low pressure L-96 Transducer. This miniature potentiometer-type unit withstands vibration levels in excess of 35 g's with less than 1% error. Two separate sets of aneroid capsules attached to opposite ends of a driving frame are utilized in the design. One set senses the driving media while the second can be evacuated for an absolute pressure reference, or vented to the atmosphere for gage measurement.

Pressure changes are transmitted through a unique, frictionless, metallic belt linkage system to position the wiper of the precision potentiometer. The fluid filled interior dampens vibration effect, provides long life and minimizes electrical noise. The unit is so insensitive to vibrations, extended dwells are allowed at any vibration frequency. Besides its excellent vibration characteristics, the L-96 has a temperature range of −65° to 275° F and a range of 0-15 to 0-350 psia or g.

For additional information about the wide pressure ranges and mounting configurations available in the L-96, write:

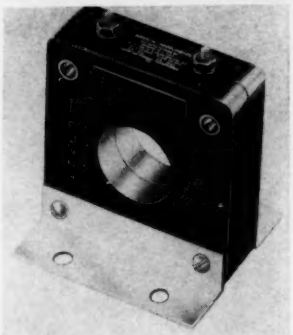
SERVONIC INSTRUMENTS, INC.

Manufacturers of pressure transducers, pressure switches, rectilinear potentiometers and slip ring assemblies.

1644 WHITTIER AVENUE, COSTA MESA, CALIFORNIA

CIRCLE 105 ON READER-SERVICE CARD

CURRENT TRANSFORMERS



New Model 605 and 607 Transformers replace Model 604, can be used with wattmeters as well as ammeters. Factory tested at 2600v ac, 60 cps for 5 sec, transformers operate at frequency of 25-800 cycles. Model 605 available in 100:5 through 400:5 ratios in 5 types; Model 607 in 500:5 through 1500:5 in 6 types.—*Daystrom, Inc., Weston Instruments Div.*, 614 *Frelinghuysen Ave., Newark* 12, *N. J.*

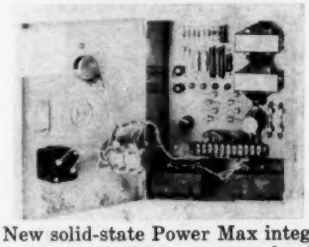
CIRCLE 232 ON READER-SERVICE CARD

REMOTE TEMP CONTROL

New "Stedi-Temp" Model 201 controls temps of liquids, solids and gases in two ranges: sensor "R" from 0° to 450°F; sensor "S" from 450° to 800°F. Normal accuracy ±2°F. Control circuit fails safe if sensor leads break.—*Electro-Flex Heat, Inc.*, 83 *Woodbine St., Hartford* 6, *Conn.*

CIRCLE 233 ON READER-SERVICE CARD

SERVOMECHANISM



New solid-state Power Max integral horsepower position servomechanism controls positioning devices requiring integral horsepower a-c induction motors and up to 1,000 ft-lb of torque with 0.5% accuracy. D-C input signals include: positioning potentiometer, selector switch and fixed resistor network, static switching circuits, etc..—*Electromation Co.*, 4254 *Glenco Ave., Venice, Calif.*

CIRCLE 234 ON READER-SERVICE CARD

solve the BIG problem in small flow measurement

Metering small flows in test labs, pilot plants and research centers with Daniel honed flow sections gives you the edge in accuracy. How? Because Daniel flow sections *give reliable duplication of performance* to overcome a big problem in small flow measurement. Each unit is manufactured just like the previous one to report the most accurate signal on any make differential recorder or indicator.

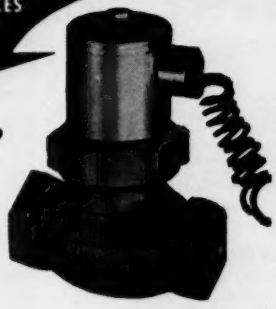
Inside diameters of each unit are honed to plus or minus .001" tolerances. Materials available . . . carbon and 316 stainless steel, others on request. Operating pressures from 0 to 1440 P.S.I. (Gage) C.W.P., 600 lbs. A.S.A. or higher. Sizes . . . ¼", ½", ¾" and 1-inch. Send for your copy of Daniel catalog section "O".

CIRCLE 106 ON READER-SERVICE CARD

Check these prices on Gould Type M

Solenoid Valves

TYPICAL USER NET PRICES
F. O. B. FACTORY



SIZE	1 to 5	100 to 499
½"	$15.40	$11.15
¾"	18.50	13.60
1"	24.25	18.50
1½"	48.00	42.40

2-Way • General Service
Packless • Normally Closed

Sizes ⅜" to 3" • Temperatures to 250° • Pressures to 400 psi • Molded epoxy resin water-proof coils • Unbreakable piston rings • No damaging hammer • Easy-off "O" ring bonnet construction in sizes ⅜" thru ¾" • High temp coils and explosion proof housings available. Immediate delivery. Ask for Bulletin 600-M.

SOME OTHER TYPES OF GOULD SOLENOID VALVES

D—Adjustable flow control, adjustable cushioning control to reduce shock, manual opening. **HV**—Four independent controls—opening, closing, flow, manual opening. **G**—Stainless, fractional ports, pressures to 1,000 psi. **GX**—All 316 stainless, fractional ports. **K**—Stainless, ½" to 2". **MDW**—Direct acting. NOTE: Special assemblies for exacting requirements.

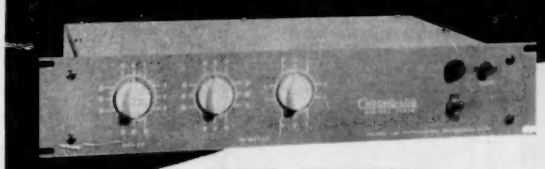
J. D. GOULD CO. · 4707 MASSACHUSETTS AVE. · INDIANAPOLIS 18, IND.

GOULD SOLENOID VALVES — VELVETROL

CIRCLE 107 ON READER-SERVICE CARD

CHRONO-LOG

DIGITAL CLOCK



FIELD PROVEN FOR THREE YEARS

Three years of field operation in hundreds of logging, computing and program control systems have proven the reliability of Chrono-log Digital Clocks and Digital Calendars.

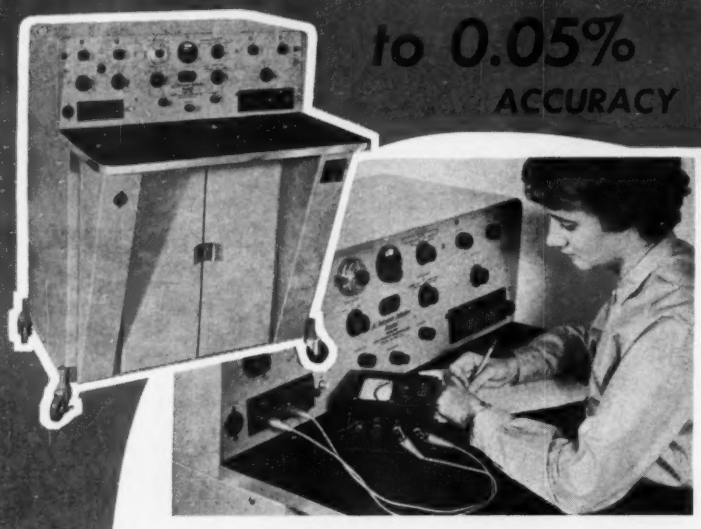
Chrono-log Digital Clocks provide electrical time-of-day readout to the nearest minute, tenth of minute or second. Up to three decimal outputs of time or one binary-coded-decimal output are available in one Clock.

For high reliability and low cost, specify Chrono-log Digital Clocks and Digital Calendars.

CHRONO-LOG CORPORATION
Box 4587 **Philadelphia 31, Penna.**

CIRCLE 108 ON READER-SERVICE CARD

AC Instrument Calibration to 0.05% ACCURACY



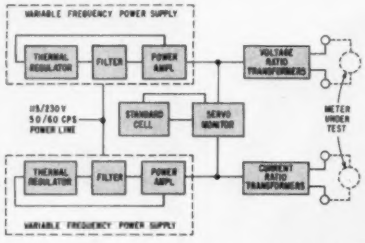
Voltmeters and ammeters, plus wattmeters, are quickly calibrated over frequencies from 50 to 2400 cps by one operator.

The Model 1967 Semi-Automatic AC Instrument Calibration Standard provides, in a single convenient console, a precise and rapid means for standardizing and calibrating alternating current wattmeters, expanded scale, digital, indicating and recording voltmeters and ammeters.

Basic accuracy is maintained by an AC reference source consisting of a servo amplifier, thermal transfer circuit and a sensitive light beam galvanometer all balanced against a ±.01% laboratory type standard cell. Resistive components are made of selected manganin properly heat-treated, aged for six months and adjusted to ±.01% of absolute value. The thermoelement is unaffected by waveform errors, has flat frequency response and is protected against overloads.

MODEL 1967 CALIBRATION RANGES

AC VOLTAGE		AC CURRENT	
RANGE	MIN. LOAD RESISTANCE	RANGE	MAX. LOAD RESISTANCE
0-1.5 MV	20,000 ohms	0-15 μA	10,000 ohms
0-3.0 MV	20,000 ohms	0-30 μA	10,000 ohms
0-7.5 MV	20,000 ohms	0-75 μA	10,000 ohms
0-15 MV	20,000 ohms	0-150 μA	10,000 ohms
0-30 MV	20,000 ohms	0-300 μA	10,000 ohms
0-75 MV	20,000 ohms	0-750 μA	10,000 ohms
0-150 MV	20,000 ohms	0-1.5 MA	1,000 ohms
0-300 MV	20,000 ohms	0-3.0 MA	1,000 ohms
0-750 MV	20,000 ohms	0-7.5 MA	1,000 ohms
0-1500 MV	1,000 ohms	0-15 MA	1,000 ohms
RANGE	MAXIMUM LOAD	RANGE	MAXIMUM LOAD
0-1.5 Volts	2 VA	0-0.15 Amp	10 VA
0-3.0 Volts	3 VA	0-0.3 Amp	10 VA
0-7.5 Volts	5 VA	0-0.75 Amp	10 VA
0-15 Volts	10 VA	0-1.5 Amp	10 VA
0-30 Volts	15 VA	0-3.0 Amp	10 VA
0-75 Volts	15 VA	0-7.5 Amp	10 VA
0-150 Volts	15 VA	0-15 Amp	10 VA
0-300 Volts	15 VA	0-30 Amp	10 VA
0-750 Volts	15 VA	0-75 Amp	10 VA
0-1500 Volts	15 VA		



We are specialists in the design and manufacture of instrument calibration consoles — offering more types than any other source in the world. Accuracy of all units is certificated and traceable to primary standards maintained by the National Bureau of Standards.

Performance is rigidly guaranteed. Prices are f.o.b. Boonton, N.J. and subject to change without notice.

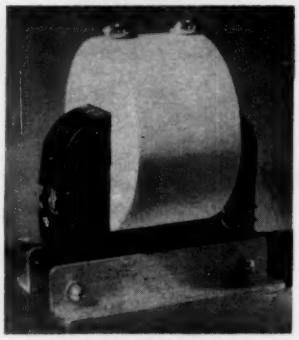
SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

RFL Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

CIRCLE 109 ON READER-SERVICE CARD

ENCAPSULATED OPEN-CORE TRANSFORMERS



New filament, isolation and high-voltage supply transformers and reactor chokes ranging from 15 to 6,000 va and with isolation to 300 kv feature windings encapsulated in epoxy-resin. Minimum size and weight for corona-free operation at rated high voltage; low capacitance; operate in air or oil.—*Components for Research Inc., 979 Commercial St., Palo Alto, Calif.*

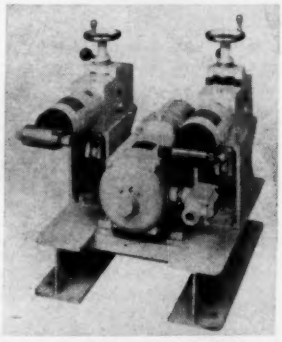
CIRCLE 235 ON READER-SERVICE CARD

DIRECT-WRITING RECORDER

New self-contained, 6 and 8 channel Direct-writing Recording Systems provide readout in ink or inkless traces on rectangular or curvilinear chart with 40-mm channels. Systems incorporate medium gain d-c amplification with basic sensitivity of 10 mv per chart division and frequency response of dc to 120 cps within 3 db at 10-mm peak-to-peak amplitude, with differential or single ended input. Imput impedance 1 to 10 megohms; chart speeds to 250 mm/sec.—*Photron Instrument Co., 6516 Detroit Ave., Cleveland 2, Ohio.*

CIRCLE 236 ON READER-SERVICE CARD

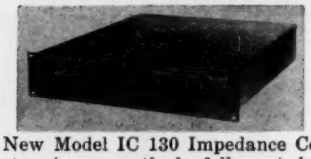
PROPORTIONING PUMPS



New simplex or duplex model (shown) Chemical Proportioning Pumps handle 0.84 to 6.44 gal fluid/hr at pressures from 7,500 to 30,000 psi. Feature adjustable stroke length which, regardless of span of travel, completely evacuates cylinder and permits efficient pumping of highly-compressible liquids. Bulletin 4068.—*American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md.*

CIRCLE 237 ON READER-SERVICE CARD

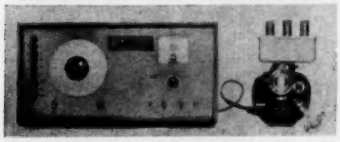
IMPEDANCE CONVERTER



New Model IC 130 Impedance Converter (super cathode follower) buffers piezoelectric transducers and other high impedance signal sources from recorders, preamps, amplifiers, etc. Isolation of circuitry and chassis from ground permits use of grounded or floating signal sources and recorders. Input impedance 1,000 megohms; 1 cps-100 kc bandwidth; 130-db common mode rejection with up to 200 v from signal source and long input cables.—*Computer Engineering Associates, Inc.*, 350 *North Halstead, Pasadena, Calif.*

CIRCLE 238 ON READER-SERVICE CARD

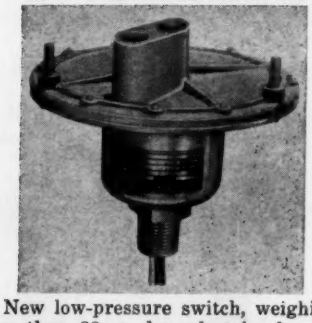
RESIDUAL GAS ANALYZER



New Residual Gas Analyzer for high vacuum applications consists of mass analyzer with magnet and d-c amplifier plus control electronics, is essentially mass spectrometer without vacuum system. Has resolving power sufficient to separate adjacent peaks up to mass 20, measures quantities of gas over mass range of m/e 2 to 80, operates from 10^{-4} to 10^{-9} mm Hg, withstands up to 450°C.—*Consolidated Electrodynamics Corp., Subs. Bell & Howell, 360 Sierra Madre Villa, Pasadena, Calif.*

CIRCLE 239 ON READER-SERVICE CARD

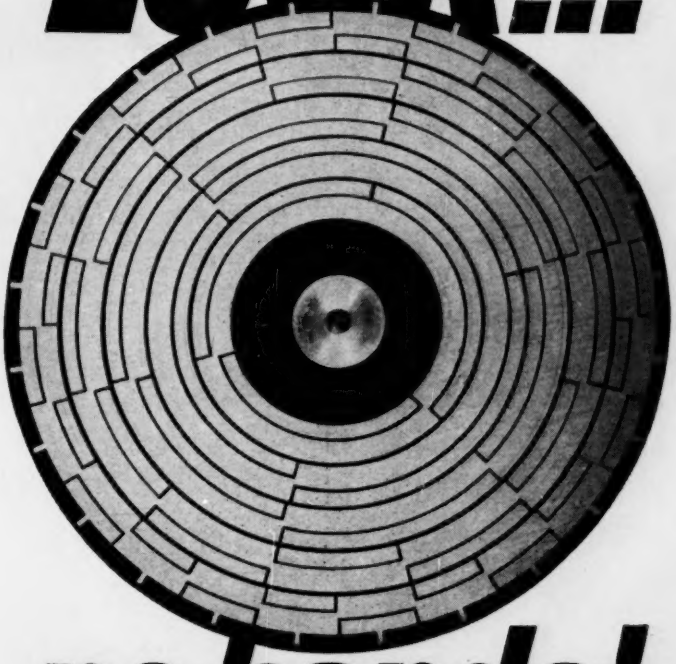
LOW-PRESSURE SWITCH



New low-pressure switch, weighing less than 22 oz, has electric element in all-metal hermetically sealed enclosure. Liquid media can be used for both reference and variable pressure with differential unit. Gage Switch Model 675 GH operates from 1" to 30" H_2O; Vacuum Model 675 VH operates from −30" Hg to 0 psi; Differential Model 675 DH, from 0 to 10 psi with differential range of 1" to 30" H_2O increasing, 0" to 27" H_2O decreasing. Proof pressure 15 psi for all models. —*Custom Component Switches, Inc.*, 3137 *Kenwood St., Burbank, Calif.*

CIRCLE 240 ON READER-SERVICE CARD

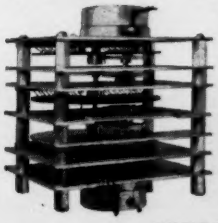
LOOK...



no hands!

This printed circuit disc is the "face" of a clock that tells time in digital code

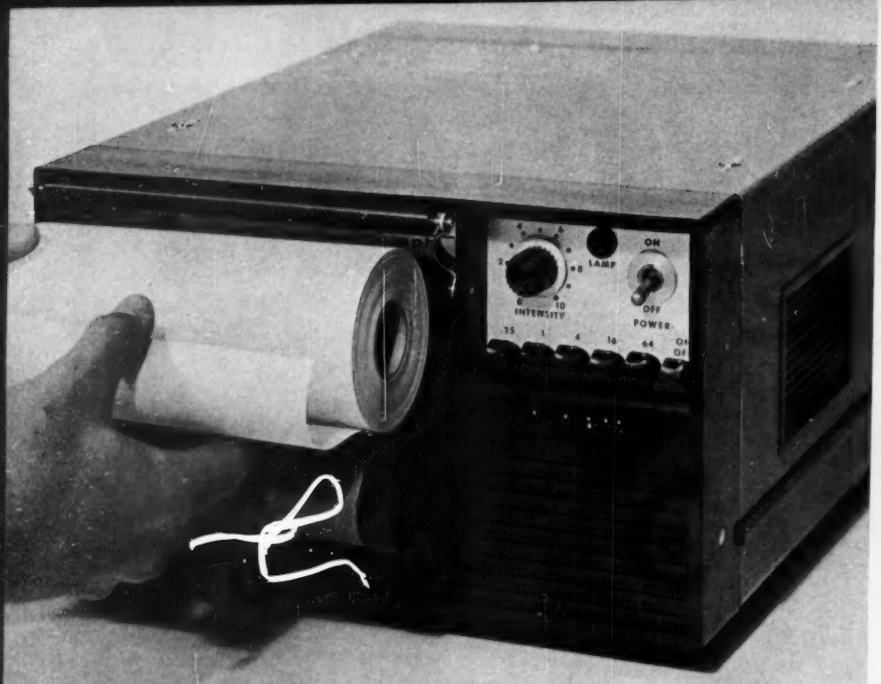
. . . or any code your computer, control system, or data processing device needs to keep it properly in touch with the world of real time.—A. W. Haydon is a company of infinite variation when it comes to such analog-to-digital converters, or "binary encoders". Time periods range from seconds to weeks. Sizes range from miniature to large. They come sealed, enclosed or open, with AC, DC, or pulse drive, and with an imposing variety of accessory equipment.—The model shown is for commerical use. It provides a discrete signal for each two-minute interval over a 28-day period. It is used, among other places, in an automatic parking lot ticket computing system.—This and several other time code generators are described in Technical Brochure SP9-2. It's yours for the asking. Similar solid-state devices can be supplied by our Culver City, Calif., facility.



THE AWH AYDON COMPANY

228 North Elm Street, Waterbury 20, Connecticut

CIRCLE 110 ON READER-SERVICE CARD



Easiest loading...

CEC's 5-124 Recording Oscillograph is ready to record in just 10 seconds

Drop in a roll of paper... at the push of a button you are ready to record up to 18 channels of data... push another button to select any of five recording speeds ranging from ¼ to 64 ips. CEC makes recording easier than ever before with the new portable 5-124 Recording Oscillograph—a "big" oscillograph that sells for considerably less than the cost of any comparable instrument.

Everything you need for loading, operating and viewing is right in front of you—including ready to read, print-out records that eliminate processing problems.

The 5-124 delivers a writing speed of 50,000 ips with trace widths of 0.010" or less—and an optional DATAFLASH* unit can speed its print-out process by a factor of 60!

For flexibility, the 5-124 has 18 individual inputs and is available with many optional features to meet your most demanding data recording needs.

For complete information, call your nearest CEC sales and service office or write for Bulletin CEC 5124-X10.

*Pat. Pend.

Data Recorders Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

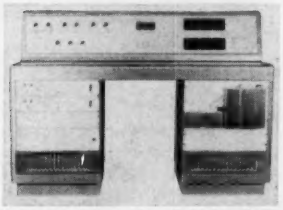
A SUBSIDIARY OF Bell & Howell • FINER PRODUCTS THROUGH IMAGINATION

PORTABLE MAGNETOMETER

New Magnetometer has 0.1-w power consumption, wide dynamic range; maintains constant magnetic field or detects minute changes ranging from 5 to 5,000 gammas. Device uses single flux-gate magnetic sensor; field cancellation control cancels out known magnetic field, measures only actual changes. With two sensing elements it becomes gradiometer; with three at right angles to each other, measures vector coordinates of any field.—*Boston Div., Minneapolis-Honeywell, 40 Life St., Boston 35, Mass.*

CIRCLE 241 ON READER-SERVICE CARD

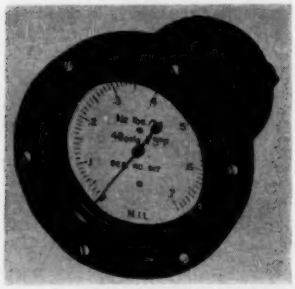
DATA SYSTEM



New Automatic Digital Data Acquistion and Recording (ADDAR) System records analog values at rates to ten 4-character points/sec, converts signals to binary-coded decimal form, converts binary decimal to teletype code, and provides digital record on five-level punched paper tape.—*Monitor Systems, Inc., Subs. Epsco, Inc., Dept. 6, Fort Washington Industrial Park, Fort Washington, Pa.*

CIRCLE 242 ON READER-SERVICE CARD

DIFF PRESSURE GAGE

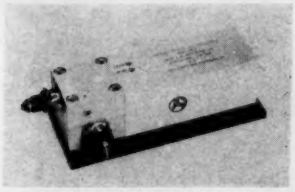


New damage-proof Differential Pressure Gages withstand full line pressure in either direction. Two sizes and ranges: 2¾" dial has full-scale ΔP range 10" water; 6" dial, 15" water. Both rated at 70 psig, 0.3% hysteresis.—*National Instrument Laboratories, Inc., 828 Evarts St., N. E., Washington, D. C.*

CIRCLE 243 ON READER-SERVICE CARD

CIRCLE 111 ON READER-SERVICE CARD

PRESSURE TRANSDUCER



New Model CP49 DC Output Variable Reluctance Pressure Transducer for voltage-controlled telemetering and other d-c systems combines variables reluctance pressure traansducer and d-c energized carrier-demodulator. Gage, Differential and Absolute models available with ranges from 5-10,000 psi. Overpressure 700 psid or 200% of range (whichever is greater); zero shift with line pressure less than 1% full scale.—*Pace Engineering Co.*, 13035 *Saticoy St., N. Hollywood, Calif.*

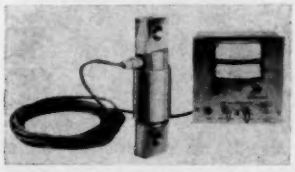
CIRCLE 244 ON READER-SERVICE CARD

MINI TAPE RECORDER

New 5" x 7" x 10½" Model PMR-500 portable magnetic Tape Recorder handles data from dc to 100 kc at 30 ips (upper frequency proportionally less at lower tape speeds) using AM and FM techniques. Accommodates any combination of record or reproduce totalling 7 channels with ½" tape on 5" reels (900' 1-mil tape), allowing 6-min recording at 30 ips, up to 96 min at 1⅞ ips.—*Pacific Electro Magnetics Co.*, 942 *Commercial St., Palo Alto, Calif.*

CIRCLE 245 ON READER-SERVICE CARD

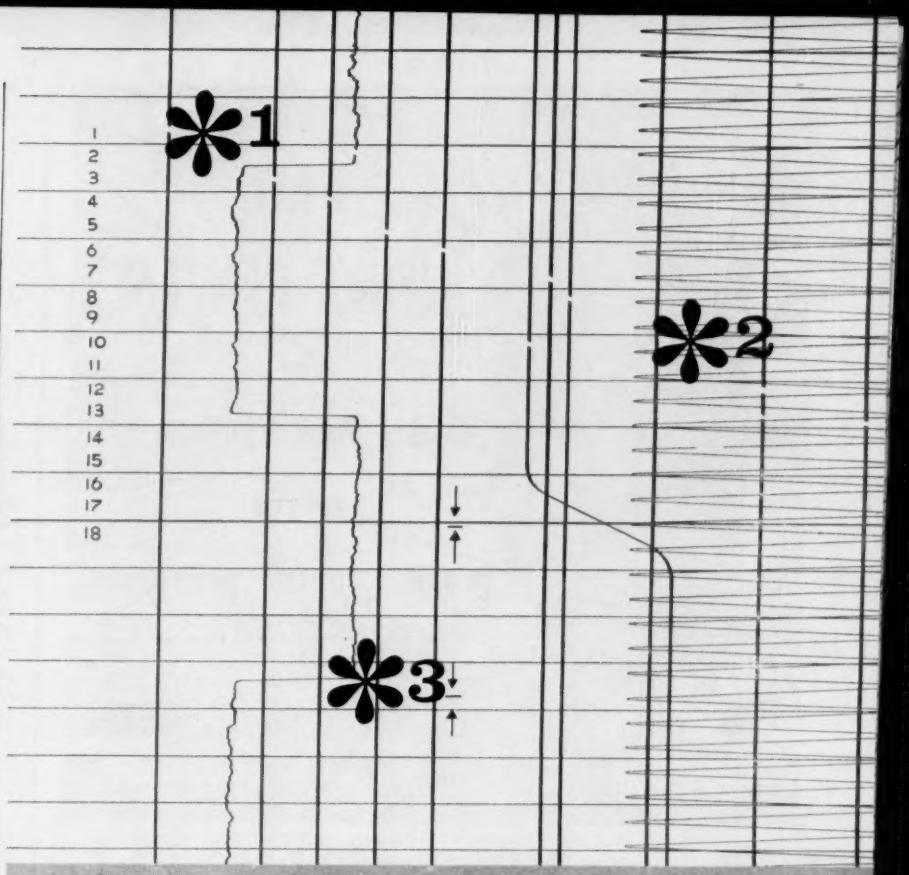
FORCE METERS



New transistorized SIDCO Force Meters measure tensional, torsional, or compressive forces to 20,000 lb with ±2% accuracy. Units consist of sensing cell, internally calibrated transistorized indicating meter, connecting cable, and battery case.—*Plastronics Div., Plastic Applicators, Inc., Box 7631, Houston 7, Texas.*

CIRCLE 246 ON READER-SERVICE CARD

CIRCLE 112 ON READER-SERVICE CARD ⟶



fastest reading!

Here's 50,000 ips writing speed with the results at your fingertips

The print-out record shown here illustrates a typical dynamic test employing 15 traces. Take special note of:

*** 1 – Trace numbering * 2 – Trace interruption**

*** 3 – Full-width timing lines (0.01, 0.1 or 1.0 sec. intervals)**

Trace identification and timing lines are optional features, as are grid lines (1/10" or mm) and galvanometer block heaters. Eighteen Type 7-300 Galvanometers are available covering a range of 1.62 microamps per inch at 6 cps and 46.1 milliamps per inch at 5000 cps.

CHECK THESE STANDARD FEATURES... ALL INCLUDED IN THE BASIC 18-TRACE TYPE 5-124 SELLING FOR $2,290

5 Pushbutton-selected speeds • 7" by 200' print-out record capacity • High intensity mercury-vapor light source • Automatically regulated galvanometer lamp circuit • Intensity control • Unexposed footage indicator • Individual input connectors • 15¼" long x 13" wide x 7⅞" high • 115 volts, 60 cps, 250 watts

For complete information, call your nearest CEC sales and service office or write for Bulletin CEC 5124-X10.

Data Recorders Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

Bell & Howell

The new W&T Massometer® senses flow in closed systems. It measures dry, free-flowing materials and translates the results into a 3-15 psi signal. The unit can be used to indicate or record. It also controls proportional blending . . . helps solve problems in all kinds of control situations.

And the Massometer does all this without breaks in your closed system. Air-tight construction means a flow-sensing unit that seals dust in . . . seals contamination out. It is compact and easily installed, fits neatly into the line. Stainless steel for parts exposed to the flow stream and dust-tight motor casing assure years of maintenance-free service.

The Massometer is calibrated with any maximum output between 40 and 200 lbs. per minute. Maximum volumetric capacity is 6 cubic feet per minute. Repeatability within ±0.2% of full scale assures stable performance.

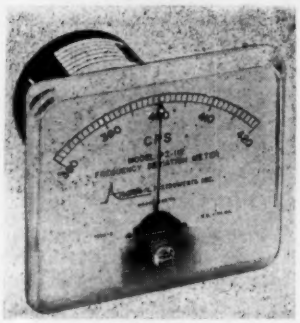
By generating a signal proportional to flow, the W&T Massometer brings a new look to ratio control. Its versatility means more accurate batch processing, or helps create continuous processing in new or existing systems.

For information, write Dept. M-50.48

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CIRCLE 113 ON READER-SERVICE CARD

FREQUENCY DEVIATION METERS



New low-cost, compact Frequency Deviation Meters for 60 and 400 cycle power lines: Model PI-111-60c (3½" meter) and Model PI-112-60c (4½" meter) have frequency range of 57-63 cps; Model PI-111-400c and Model PI-112-400c (3½" and 4½" meters) have 380-420 cps range. Require less than 2 watts; signal voltage 100-135 v ac rms; resolution of 0.05%, and 0.1% accuracy.—*Anadex Instruments, Inc.*, 14734 *Arminta St., Van Nuys, Calif.*

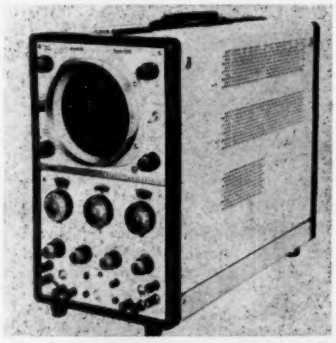
CIRCLE 247 ON READER-SERVICE CARD

VOLTAGE DIVIDER

New Model VDR-105 secondary standard Voltage Divider (inexpensive version of VDR-106) is used for: calibrating resistance-ratio sets, measuring relative voltage, current or resistance over wide ranges, standardizing lab instruments. Unit is 5-decade Kelvin-Varley divider, with accuracy, resolution and long-term stability rated at 0.001% (vs 0.0001% of 6-decade VDR-106).—*Julie Research Laboratories, Inc.*, 603 *W.* 130 *St., New York* 27, *N. Y.*

CIRCLE 248 ON READER-SERVICE CARD

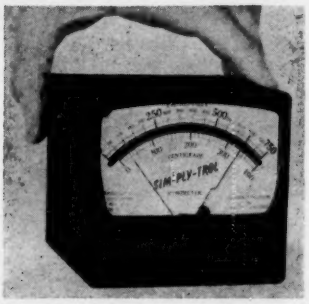
DUAL-TRACE SCOPES



New Dual-Trace Oscilloscopes, Types 1120 Portable and 1120-R Rack-Mountable, simultaneously display two vertical signals against time, against each other (X-Y plots), or vs third variable fed externally to X-axis. Frequency response, flat dc to 500 kc (3db), 10-cm undistorted deflection at 1 Mc.—*Analab Instrument Corp.*, 30 *Canfield Rd., Cedar Grove, N. J.*

CIRCLE 249 ON READER-SERVICE CARD

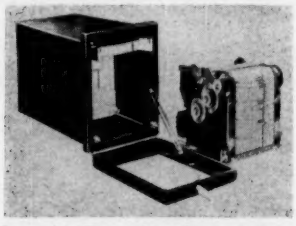
METER-RELAY CONTROLS



New Model 450 meter-relay controls, 4¼" x 4" x 5½", accurate to ±1°F, use proportioning action to minimize over-shoot of set point and produce almost flat temp curve. Eight standard ranges between 300° and 2500°F. Samples signal from heat source, turns heat on and off; rate field-adjusted by moving lug on terminal strip.—*Assembly Products, Inc., Chesterland, Ohio.*

CIRCLE 250 ON READER-SERVICE CARD

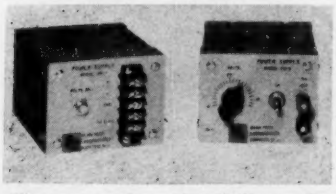
STRIP-CHART RECORDER



New A+ Record galvanometer recorder accurate to ±1.0% requires 400 μw (without amplifier) for full response within 0.6 sec, permits equipment manufacturers to obtain coil resistances and damping resistances to match circuit characteristics. Ink pen, hot wire, or Teledeltos writing systems, ½" to 12" per hr or per min on single-speed mechanisms. Replacing 2 or 4 wheels in gear train changes speed.—*Atkins Technical Inc.*, 1276 *W.* 3 *St., Cleveland* 13, *Ohio*

CIRCLE 251 ON READER-SERVICE CARD

POWER SUPPLIES



New compact regulated Power Supplies (0.25-amp output Model 170 and 0.50-amp output Model 171) are available in bench, plug-in, and terminal strip versions. Voltage outputs variable from 10-32 v with regulation better than 3 mv, line or load. Ripple held to less than 250 μv, rms.—*Quan-Tech Laboratories, Inc.*, 60 *Parsippany Blvd., Boonton, N. J.*

CIRCLE 252 ON READER-SERVICE CARD

MEASURE ABSOLUTE PRESSURES

with SPEED and PRECISION

With Wallace & Tiernan Aneroid Dial Indicators you get precision and fast response in all types of absolute pressure work.

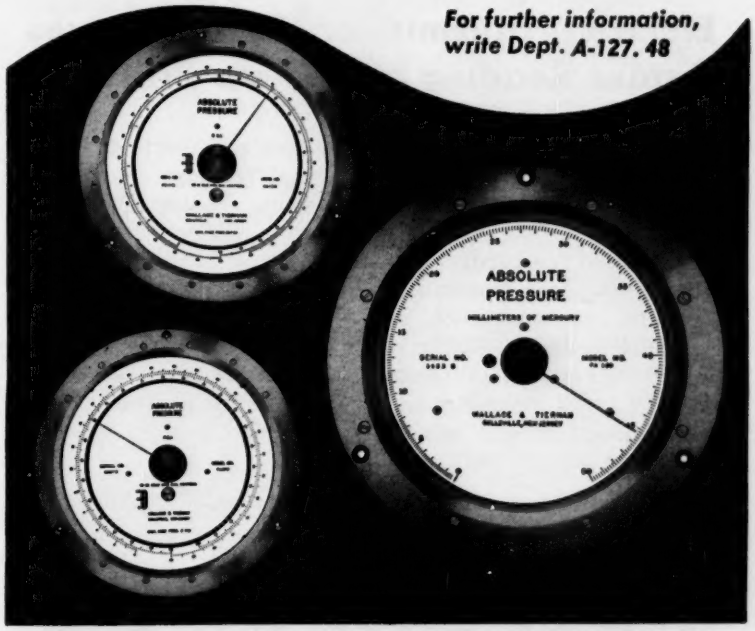
W&T Precision Indicators have many uses in research and development engineering. One is ideal for calibrating pressure transducers; another, for checking the calibration of flight instruments and ground support equipment. These instruments also keep constant check on continuous production-line work.

A W&T Absolute Pressure Gauge on the job means:

- ★ Accuracy 0.1% to 0.33%
- ★ Sensitivity 0.01% to 0.2%
- ★ Range 0.1-20 mm Hg to 0-500 p.s.i.a
- ★ No corrections
- ★ Light weight, small size

The accuracy of W&T Absolute Pressure Indicators approaches that of liquid columns... higher sensitivity assures faster response... large dial gives quick reading.

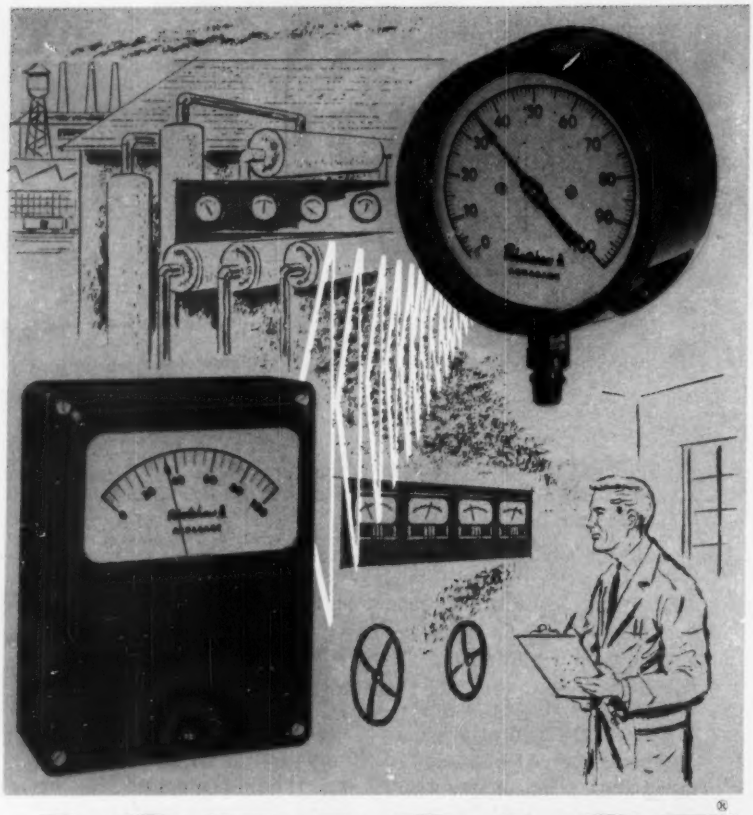
For further information, write Dept. A-127. 48



WALLACE & TIERNAN INCORPORATED

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CIRCLE 114 ON READER-SERVICE CARD



ACRAGAGE®

Electric Transmission System Gives Instant Reading of Remote Pressures

From remote process points at any reasonable distance, Acragage Electric Transmitters signal pressure changes to your central control panel for immediate reading and necessary action.

Now in full production at Robertshaw's Knoxville plant, this trouble-free transmission system is available for fast delivery . . . and quick, efficient solution to your remote pressure-reading problems.

Rotary type potentiometer in transmitter assures accuracy to ±1%, with instantaneous response. Large, easy-read dials on transmitters and receivers; available for flush or wall mounting.

Full specifications and ranges in new folder EL–763.

Robertshaw®

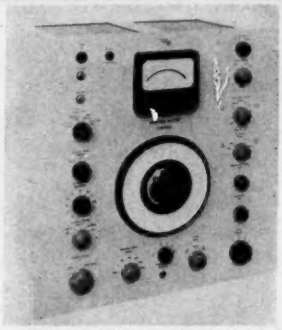
MR. CONTROLS

Robertshaw-Fulton Controls Company

FULTON SYLPHON DIVISION • KNOXVILLE 1, TENNESSEE

CIRCLE 115 ON READER-SERVICE CARD

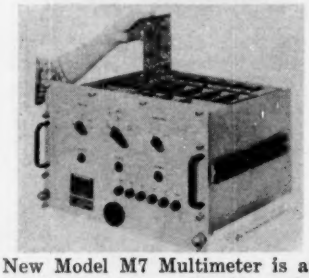
VIBRATION EXCITER CONTROL



New Model N572 automatic Vibration Exciter Control is electronic servo which maintains constant acceleration or constant displacement at vibration exciter as frequency changes. Automatic or manual correction rate; sweep rate adjusts from 1-100 minutes through 10-2000 cps and back. Any part of 5-5000 cps frequency band can be cycled continuously within ±10% of center frequency.—*MB Electronics*, 781 *Whalley Ave., New Haven* 8, *Conn.*

CIRCLE 253 ON READER-SERVICE CARD

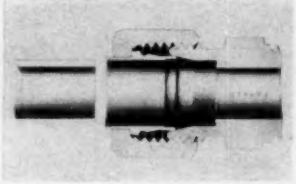
AN-DIG CONVERTER



New Model M7 Multimeter is analog-digital converter. Can be used for automatic checkout applications, to measure frequency from 1 cps to 100 kcs accurate to 0.01% ± 1 count in 0.1 sec, periods from 0.001 to 0.1 sec accurate to 0.01%, voltage and resistance ranges from 1000 v ac or dc to 1 megohm, etc.—*Packard Bell Computer Corp., Div. Packard Bell Electronics*, 1905 *Armacost Ave., Los Angeles* 25, *Calif.*

CIRCLE 254 ON READER-SERVICE CARD

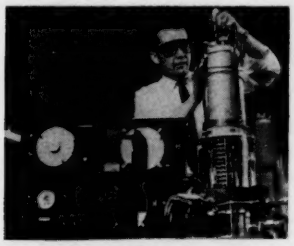
TUBE FITTING



New Intru-lok tube fitting has elongated "snap-in" ferrule held captive by nut. Tube is inserted through assembled fitting to shoulder inside body, nut is tightened, ferrule bites into outer surface of tube. Larger opening in new nut clears bends in tubing.—*Parker Fittings & Hose Div., Parker-Hannifin Corp.*, 17325 *Euclid Ave., Cleveland* 12, *Ohio.*

CIRCLE 255 ON READER-SERVICE CARD

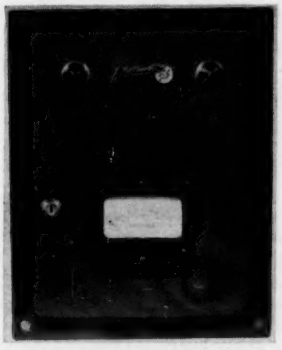
CHROMATOGRAPHIC SYSTEM



New Model 284B high-speed Process Vapor Fractometer for multi-component process streams includes analyzer (right), programmer (left), memory (lower left), and transmission units. Control signals of 0-4 mamp, 0-50 v, proportional to concentrations of measured components. With mamp-to-psi transducer, suitable for pneumatic control systems.—*Perkin-Elmer Corp., Norwalk, Conn.*

CIRCLE 256 ON READER-SERVICE CARD

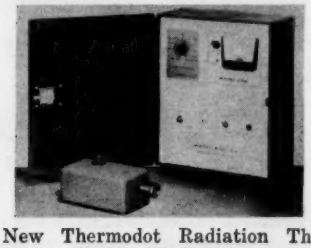
COMBUSTION INDICATORS



New Hazegage Combustion Indicators monitor boilers and serve as smoke indicators. Red and green lights on panel board indicate combustion conditions without observation lag. No CO_2 sampling necessary.—*Photomation, Inc., 96 S. Washington Ave., Bergenfield, N. J.*

CIRCLE 257 ON READER-SERVICE CARD

RADIATION THERMOMETER



New Thermodot Radiation Thermometer Model TD-6 measures and controls temp without contact from 210° to 3300°F, is compensated for ambient from 50° to 120°F (to 175°F with optional water cooling). Response time 0.3 sec, sensitivity 0.2% of temp, focusing range 20" to infinity.—*Radiation Electronics Co., Div. Comptometer Corp., 5600 Jarvis Ave., Chicago 48, Ill.*

CIRCLE 258 ON READER-SERVICE CARD

DOUBLE TALK!

MAKES SENSE WITH EECo ALL SOLID-STATE DATA CONVERTERS FOR OFF-LINE DUTY

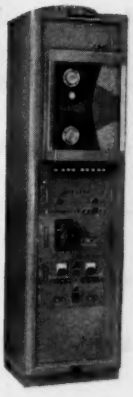
One data language in. Another out. Fast, accurate performance and long service life, at new, low cost. Off-line operation to conserve valuable computer time.

EECo-753 3-Way Tape Data Converter

for business or scientific use

• Paper-to-Magnetic Tape • Magnetic-to-Paper Tape • Paper-to-Paper Tape — 5-, 6-, 7-, or 8-level paper tape in any coding in or out. IBM 704 or IBM 705 magnetic tape in or out. Selectable block lengths up to 720 characters stored in ferrite core memory. Manual-visual check of code conversion and memory.

PRICE $62,500 fob Santa Ana

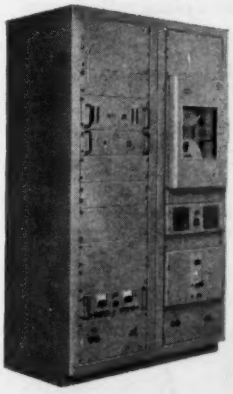


EECo-752 Data Converter

for business or scientific use

Converts 5-level Teletype paper tape to magnetic tape for IBM 704 or IBM 705. Manual-visual check of code conversion and memory. 128-character ferrite core memory.

PRICE $36,500



EECo-751 Format Control Buffer

for scientific use

For entry into IBM 650, IBM 704, IBM 705, IBM 709. Or can be furnished for other computers. Accepts digitized data in parallel form at random rates.

PRICE $38,500-$45,000

SEND FOR DATA FILE 751-3. All converters employ Engineered Electronics Co.'s all-solid-state plug-in circuits throughout.

Electronic Engineering Company *of California*

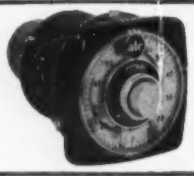
1601 E. Chestnut Avenue • Santa Ana, California • KImberly 7-5501 • TWX: S Ana 5263

MISSILE & AIRCRAFT RANGE INSTRUMENTATION • DIGITAL DATA PROCESSING SYSTEMS • TIMING SYSTEMS • COMPUTER LANGUAGE TRANSLATORS • PAPER TAPE PROGRAMMERS

EE 0-18

CIRCLE 116 ON READER-SERVICE CARD

SERIES 305—Controls up to 6 individual load circuits; easily changed from "Reset" to "Non-Reset."



SERIES 306—Controls 2 separate adjustable load circuits; built-in dwell protects reversing motors.

SERIES 304—Percentage Timer; integral "On-Off" control eliminates separate switch.

SERIES 307—Revolution Counter; permits direct connection to flexible cables, differential couplings, gears, rotating shafts.

TIMERS FOR AUTOMATIC CONTROL

SPLIT SECONDS OR HOURS ACCURATE...RUGGED

Now you can order off-the-shelf timers for every industrial control application, including highly complex control functions involving hundreds of timed or sequential operations. ATC offers the widest line of standard timers, plus complete design and engineering assistance to meet special requirements. These unique features mean more dollar value from ATC timers:

Easy one-hole mounting in standard 3 3/16" cut-out. **Fully insulated ring clamp replaces screws.**

Change cycle any time with handy large knob. **Cover slips off without disconnecting timer from service.** **One piece rolled cover has integral printed wiring schematic.**

Write now for new illustrated Condensed Catalog; contains complete specifications and performance data.

atc

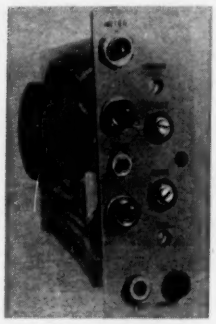
AUTOMATIC TIMING & CONTROLS, INC.

KING OF PRUSSIA, PENNSYLVANIA

A SUBSIDIARY OF SAFETY INDUSTRIES, INC.

CIRCLE 117 ON READER-SERVICE CARD

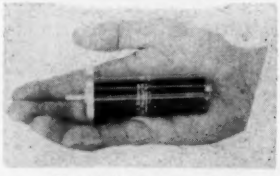
MONITOR ALARM



New solid-state Magne-Alarm uses bistable magamp as driving-sensing element, monitors mv-output from thermocouples and low-level sensors. Indicates visually at all times, brightens and sounds alarm for out-of-limit conditions, will not trigger on random noise. Input range 0-25 mv, input resistance 1000 ohms min.—*San Diego Scientific Corp.*, 3434 *Midway Dr., San Diego* 10, *Calif.*

CIRCLE 259 ON READER-SERVICE CARD

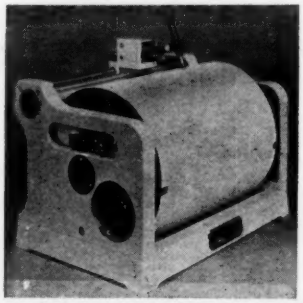
TACHOMETER



New 45-v/1000-rpm Model SU-780D-1 Tachometer (1-⅛" dia x 3-½") achieves high output with increased armature length. Neoprene seal on outer shaft bearing prevents contamination; enclosed output terminals prevent external shorts.—*Servo-Tek Products Co.*, 1086 *Goffle Rd., Hawthorne, N. J.*

CIRCLE 260 ON READER-SERVICE CARD

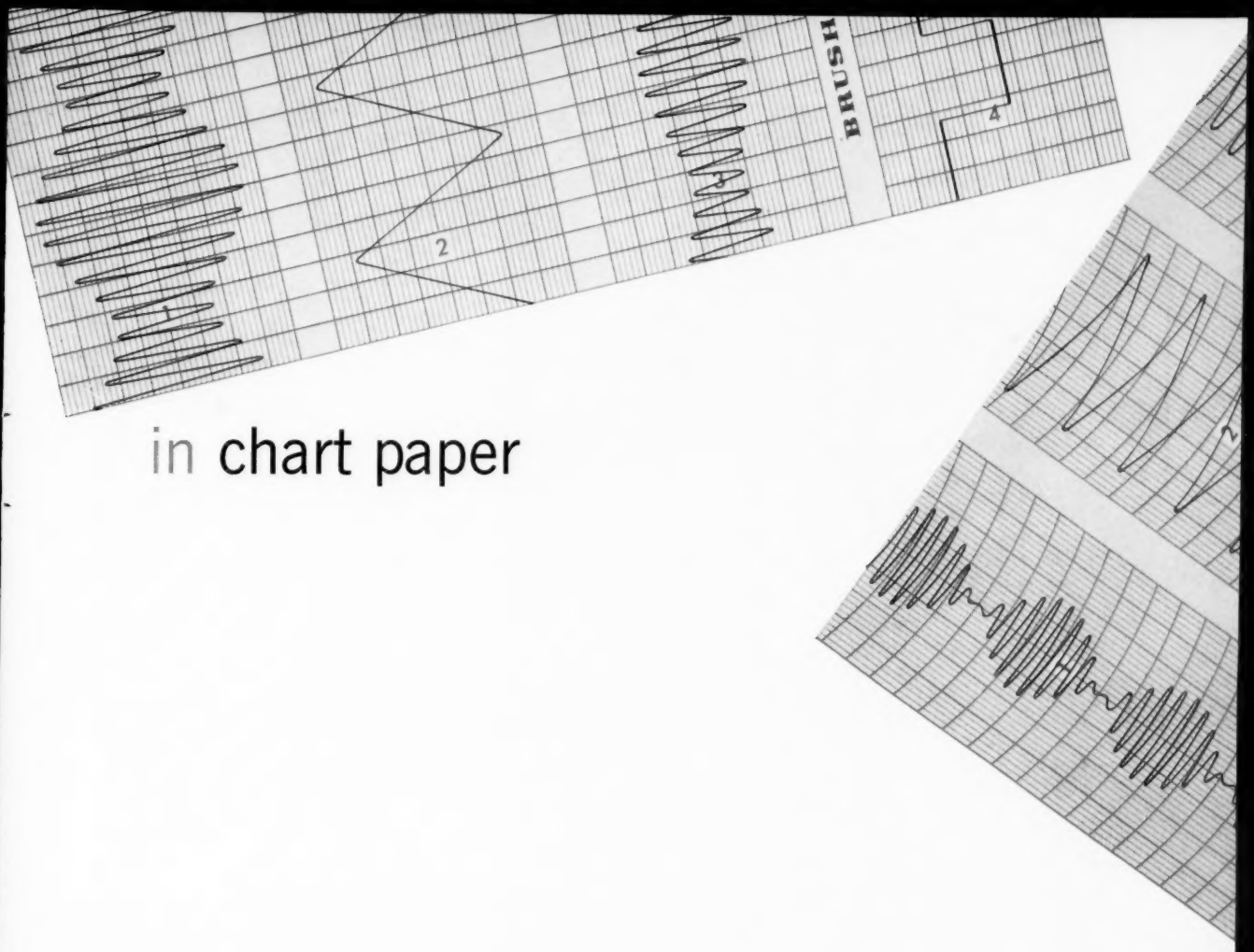
DRUM CHRONOGRAPH



New lightweight Drum Chronograph, field tested under demanding conditions, produces continuous 39-meter time record on standard chronograph paper—approximately 65 minutes of recording time. Escapement-type 12-v d-c motor; 6-v d-c solenoid coil drives pen.—*Ruska Instrument Corp.*, 2503 *Robinhood, Houston, Texas.*

CIRCLE 261 ON READER-SERVICE CARD

CIRCLE 118 ON READER-SERVICE CARD→



in chart paper

there
is
a
difference

brush INSTRUMENTS
DIVISION OF
37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

Only Brush Chart Paper is designed as an integral component of precisely engineered Brush Direct Writing Recording Systems. The full potential of these systems cannot be realized unless *all* of the original components are utilized. They're engineered as a *total* entity. Imitation papers cannot match the precision ruling, dimensional stability and super-smoothness of Brush Chart Paper. Take no chances—specify *Brush* and you can rely on your records being accurate, permanent, easily read and easily reproduced. Stocks available from strategically located branches and sales representatives throughout the United States and Canada.

Write for samples of actual tracings on Brush Chart Paper. Ask for "Brush Engineered Recording Supplies".

CRESCENT

POLYETHYLENE MULTITUBE

VALUE

INDIVIDUALLY NUMBERED TUBES—Numbers in white appear at 2-1/2" intervals throughout the length, thus permitting positive identification of every tube anywhere along the length, as well as at each end.

BLACK POLYETHYLENE TUBES—Pigmented, high molecular weight virgin polyethylene Type P tubes are employed for maximum resistance to environmental stress cracking and aging in sunlight.

THREE STANDARD TYPES TO MEET YOUR SPECIFIC NEED

CRESCENT POLYETHYLENE MULTITUBE is composed of 2 to 37 individually numbered, black Type P tubes spirally cabled together for greatest flexibility and to eliminate distortion and stress on the tubes when bent to a small radius. The tubing assembly is protected against mechanical injury by a flexible, interlocked, galvanized steel armor, or a polyvinyl chloride (PVC) sheath or a combination of both where it is desired to protect the metallic armor against corrosion.

STANDARD TYPES

TYPE PA—Interlocked metallic armor provides complete mechanical protection to the inherently corrosion resistant tubing.

TYPE PAT—Polyvinyl chloride sheath over the armor adds corrosion protection for the armor. Can be buried in the earth.

TYPE PT—PVC sheath gives limited mechanical protection. For use in troughs, trays or conduit.

CRESCENT POLYETHYLENE PRECISION INSTRUMENT TUBING—TYPE P developed through extensive research, improved manufacturing methods and rigid test standards, will continue to be available in 1/4", 3/8" and 1/2" OD sizes in up to seven bright colors and black for use as single tubing behind panels and in MULTITUBE when specified.

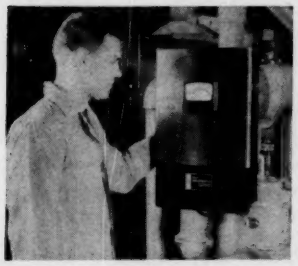
Send for Bulletin No. 960-A

CRESCENT INSULATED WIRE & CABLE CO., INC.

TRENTON, NEW JERSEY

CIRCLE 119 ON READER-SERVICE CARD

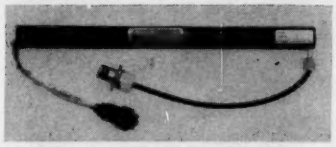
COMBUSTION INDICATOR



New Qual-O-Rimeter Combustion Indicator detects and indicates changes as small as 5 Btu in fuel gas and ±0.5% air in air/gas mixture in 5 seconds, also changes in flame geometry. Functions by presampling air/gas mixture, permits adjustment of ratio in industrial production to meet time-temp cycles.—*Selas Corp. of America, Dresher, Pa.*

CIRCLE 262 ON READER-SERVICE CARD

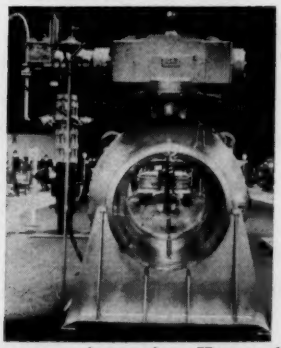
BACKWARD WAVE OSCILLATOR



New Model OD 10-15 hard glass and metal, high-vacuum, helix-type Backward Wave Oscillator provides 10-mw power output level and higher over 10 to 15.5 kmc frequency range, thus is desirable signal source for microwave swept signal generators, etc. Output connection is "M" band waveguide on RG55U coaxial cable; input, type PM6P hooded plug.—*Stewart Engineering Corp., Santa Cruz, Calif.*

CIRCLE 263 ON READER-SERVICE CARD

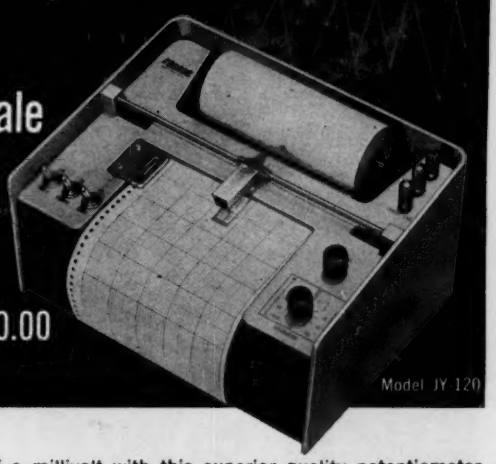
LUBRICATED PLUG



New round-opening Hypresphere Lubricated Plug Valves provide complete range of sizes (12"-36") for gas, crude oil and product pipeline use. Valves turn on and off with power operators, allowing remote control. Positive shut-off, leak-proof lubricant seal, self-adjusting plug and protected seats.—*Rockwell Manufacturing Co., Meter & Valve Div., 400 N. Lexington Ave., Pittsburgh 8, Pa.*

CIRCLE 264 ON READER-SERVICE CARD

NEW *Nesco*
GRAPHIC RECORDER
· 1 MV full scale
• maximum signal source resistance: 50 K ohms
Recorder prices start at $320.00



You can measure 1/100th of a millivolt with this superior quality potentiometer recorder. Unit is extremely accurate (½% of span), and fast (½ second balance time). Step selection of ranges up to 10 V is provided by attenuator on front panel.

Standard features include a floating input with separate chassis ground . . . 5" chart width . . . hum suppressor . . . chopper stabilization . . . changeable chart speeds. Write for Bulletin.

10 MV fixed span	$320.00	Model JY-100
10 MV to 100 V	$395.00	Model JY-110
1 MV full scale	$535.00	Model JY-120

Nesco INSTRUMENTS, INC.

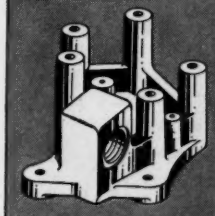
Manufacturers of Precision Recording Instruments

638 West 17th St., Costa Mesa, Calif.

CIRCLE 120 ON READER-SERVICE CARD

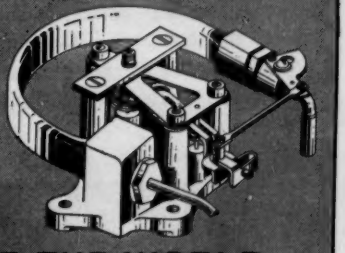
HEISE GAUGES

Minimize Recalibration Costs



Laboratory installations using Standard Inspection Control systems most frequently specify the rugged dependability of Heise Gauges to reduce inspection and recalibration frequency.

Calibration error resulting from minor displacement of the structural members of commercial gauge movements is entirely eliminated by the "integral" design of the Heise Gauge.



The universal acceptance of the Heise Gauge as a test standard for pressure sensing instruments is a continuing evidence of its performance as

THE STANDARD OF THE WORLD

HEISE BOURDON TUBE COMPANY, INC.

BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

CIRCLE 121 ON READER-SERVICE CARD

Series 610 Pressure or Vacuum Switch shown above.
Operating range 1 to 100 psi, and 30 in. hg. to 0. Proof: 1000 psi.
Mounts in any position. Wt. 10 oz. List price $40.00 F.O.B. Burbank.

TESTED AND PROVED BY 8 YEARS IN AIRCRAFT AND INDUSTRIAL SERVICE

Check these features: Accurate to ±1% of actuation point. Vibration proof • Withstands high impulse cycling—no coils or restrictors required • Positive setting—no drifting of actuation point with varying temperatures • Eliminates difficulties of severe pump ripple • Incorporates hermetically sealed snap-action switch.

Explosion-Proof *Listed under Re-examination Service of Underwriters' Laboratories, Inc. for hazardous locations Class I Group A, B, C & D; Class II Group E, F & G.

Don't gamble with safety, be sure the switch you specify carries this complete listing.

Write today for complete information on the exclusive CC Dual-Snap switch design, catalog data and name of your nearest representative.

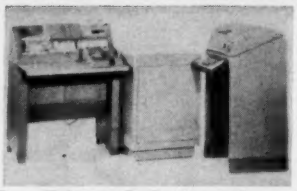
Complete line of pressure, vacuum and differential switches.

CC DUAL-SNAP PRESSURE SWITCHES

CUSTOM COMPONENT SWITCHES, INC.
3137 Kenwood Street • Burbank, California

CIRCLE 122 ON READER-SERVICE CARD

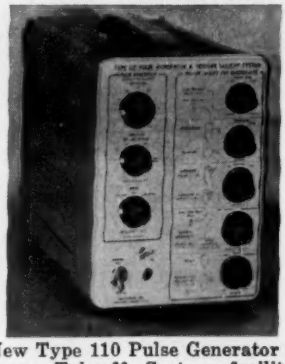
TELEPUNCH INTERCOUPLERS



New Telepunch Intercouplers provide direct machine-to-machine connection between IBM Card Punches and standard Model 28 Teletype sending and receiving sets. Model T585 transmitter transmits from IBM Cards or 8-channel punched tape directly to standard teletype equipment (local page print-out if desired). Model T8045 Card Receiver provides automatic, on-line card punching of incoming teletype messages. Timing Module governs Teletypewriter speeds (60, 75, and 100 words/min).—*Systematics, Div. General Instrument Corp., Hawthorne, Calif.*

CIRCLE 265 ON READER-SERVICE CARD

PULSE GENERATOR



New Type 110 Pulse Generator and Trigger Takeoff System facilitates measurement of amplifier linearity, and trigger sensitivity to amplitude or pulsewidth changes. Pulse risetime less than 0.25 nanosec; repetition rate nominally 720 pulses/sec; output impedance 50 ohms. Independent Trigger Takeoff System provides stable triggering over range of signal amplitudes down to 50 mv. Trigger regenerator output (±10 v, 4 nsec 50% rise-time, 225 nsec duration) triggers oscilloscopes with relatively slow trigger responses, starts Type N Sampling Unit when source cannot supply suitable trigger.—*Tektronix, Inc., Box 500, Beaverton, Ore.*

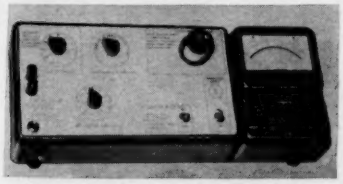
CIRCLE 266 ON READER-SERVICE CARD

THERMOCOUPLE REF JUNCTION

New Model TRJ 3006 elevated temp Thermocouple Reference Junctions are basically stable devices designed around on-off type temp control system which operates on small temp differential. Cycling temp effect dampened by heat sink, variation less than ±1/6°F from 30° to 275°F.—*Temptron Inc., 7030 Darby Ave., Reseda, Calif.*

CIRCLE 267 ON READER-SERVICE CARD

INCREMENTAL ANALYZER



New Incremental Analyzer for determining very small increments or deviations about a norm has drift of 0.1% of reading. Use of Simpson "Add-a-Tester" adaptors and Simpson 270 volt-ohmmeter increases versatility, allows recorder adaptor to act as deviation analyzer.—*Tensor Electric Development Co., Inc.*, 1873 *Eastern Parkway, Brooklyn 33, N. Y.*

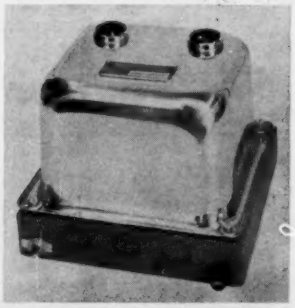
CIRCLE 268 ON READER-SERVICE CARD

TORQUE GAGE

New TGRL Series Torque Gages register clockwise or counter-clockwise torque in same direction on same scale accurate to ±1%. Two models, 5-oz and 7-½ oz; 8 ranges; 0-2 in-oz with ⅛ in-oz increments on one scale to 144-216 in-oz with ½ or 1 in-oz increments on one scale.—*Torque Controls, Inc.*, 829 *E. Broadway, San Gabriel, Calif.*

CIRCLE 269 ON READER-SERVICE CARD

CONDUCTIVITY CONTROLLER



New Model RGC-11 Conductivity Controller uses magnetic rather than vacuum tube amplification for on-off control; avoids drift on aging, tube replacement, and sensitive relays. SPDT relay (10-amp) operates off output of magamp. For applications from pure water to very conductive solutions.—*Industrial Instruments, Inc.*, 89 *Commerce Rd., Cedar Grove, N. J.*

CIRCLE 270 ON READER-SERVICE CARD

Name Your Application!

Do It Better With *ThermoElectric* Thermocouple Extension Cables and Wires

You can obtain Thermo Electric thermocouple extension wire and cable in the widest variety of size, insulation, type and calibration, for your application—with prompt delivery of all standard materials.

New on the stock list, is the time and labor saving THERMO-CABLE*, from 6 to 56 matched pairs of I.S.A. color-coded thermocouple leads, individually insulated in PVC — collectively wrapped in "Mylar" tape—with a tight-fitting PVC outer sheath. THERMO-CABLE is practically impervious to moisture, abrasion, temperature, gasses and chemicals. Saves you the time, cost and effort of pulling individual wires through conduit.

Individual or duplex thermocouple and extension wires are available in all standard calibrations — many in gages from 14 to 40—insulated with Polyvinyl Chloride, cotton lacquer, Nylon, Teflon, Fiberglass, Asbestos or combinations of these materials. Metallic overbraids of stainless steel and other high-temperature materials provide extra mechanical protection and shielding.

CERAMO®, Thermo Electric's metal-sheathed ceramic insulated thermocouple wire is used for extra-high temperature and nuclear applications. Thermo Electric also supplies thermocouple wires to meet Mil-Spec requirements.

For information on selecting the right wire for your application,

write today for Bulletin 32-W5-12

*Trade Mark

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

CIRCLE 102 ON READER-SERVICE CARD

Moeller Exclusives Provide Timeless Accuracy

Moeller Mercury-Actuated-Dial-Indicating Thermometers are designed and constructed to provide dependable accuracy with minimum maintenance. They are available both in direct reading and remote types.

Gasketed phenolic cases are furnished in 4½", 6" and 8" sizes for flush or surface panel mounting. Brass cases can be furnished on special order.

Standard ranges are supplied between —40°F. and +1200°F. Special ranges and combination scales can be made to order. The bourdon spring, which is the heart of the instrument, is specially designed and heat treated for long life and accuracy.

Moeller Micro accurate stainless steel capillary tubing has a smooth internal diameter, held to close tolerance. Standard armor is spirally wound stainless steel. Other armors such as smooth lead, polyvinyl chloride, etc., are also available. Tubing lengths can be furnished up to 150 ft. Lengths over 50 ft. may be ordered with full compensation. Anti-parallax scales are standard.

All dials are compensated for temperature variations around the case. Units are available with plain bulbs, union connection bulbs and separable sockets. Separable sockets also can be fabricated from all commercial metals with thread, flanged and Van Stone connections.

Dial thermometers can be furnished with high and low alarm contacts.

Moeller has a dial thermometer to meet your specific needs. See your Moeller Representative or write today for Catalog No. 150.

Adjustable Dial Indicating Thermometer

Remote Reading Dial Indicating Thermometer

Dial Thermometer with two adjustable electrical contacts

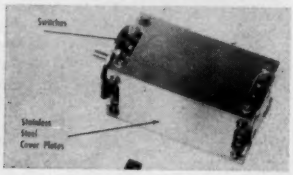
SINCE 1867

MOELLER INSTRUMENT COMPANY, Inc.
132nd Street and 89th Avenue, Richmond Hill 18, N.Y.

Representatives in principal cities.

CIRCLE 124 ON READER-SERVICE CARD

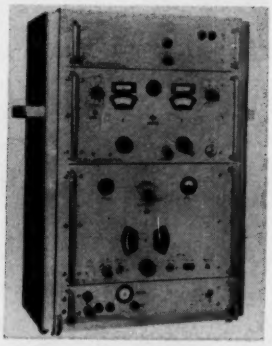
LIMIT STOP ASSEMBLY



New 50-turn Limit Stop Assembly accomodates up to 8 settings, operates by push-rod-plunger assemblies. Switch actuation accurate to ±5° or 0.027%. On cam-actuated switch can be added, will repeat to ±2° or 0.011%. Units include anti-backlash device, end-position energy-absorbing springs.—*United Control Systems, Inc., 918 Woodley Rd., Dayton 3, Ohio.*

CIRCLE 271 ON READER-SERVICE CARD

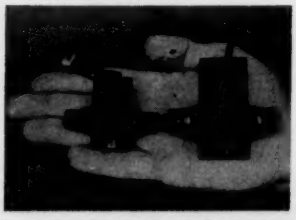
FREQUENCY SYNTHESIZER



New FD-3 Synthesizer has fundamental frequency range of 300-1000 mc with crystal source accuracy and stability. Harmonic range, with additional mixer, up to 30 kmc. Companion FDS-3 Syncriminator permits phase locking of klystrons and backward wave oscillators to accuracies of FD-3 unit.—*Industrial Products Div., International Telephone and Telegraph Corp., 15191 Bledsoe St., San Fernando, Calif.*

CIRCLE 272 ON READER-SERVICE CARD

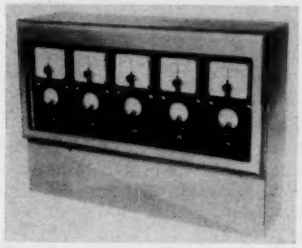
3-WAY MICRO VALVES



New 3-way Micro Valves feature male pipe connections which turn, permitting installation without unions; fast, positive snap-action; operation to 100 psi; varied orifice sizes, materials, and types of operators. Two or more valves manifold together for multiple operation.—*Instruments, Inc., Box 556, Tulsa, Okla.*

CIRCLE 273 ON READER-SERVICE CARD

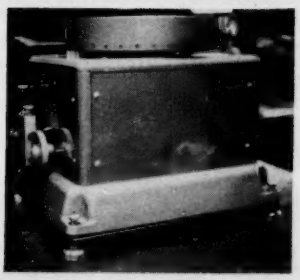
GAS DETECTOR



New Model 520 Multitector provides monitoring of hazardous gases in 5 areas up to 1500' from unit. Each detection point has measuring circuit, indicator, adjustable alarm. Indication read directly in % Lower Explosion Limit; adjustments and calibration made at central panel.—*Houston Instrument Corp., Box* 22234, *Houston* 27, *Texas.*

CIRCLE 274 ON READER-SERVICE CARD

BELT-DRIVEN TURNTABLE



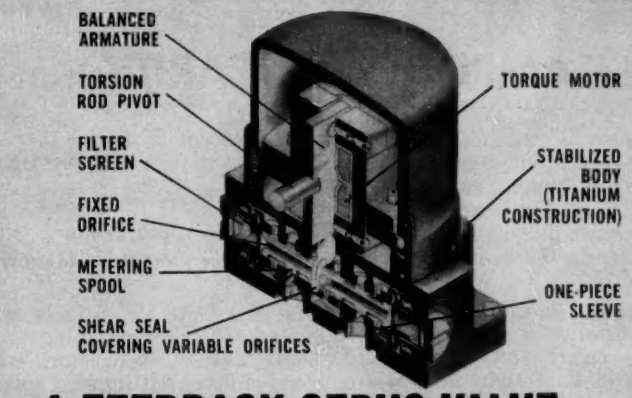
New Model 1252 BH belt-driven, bench-model turntable has 50-lb capacity, less than 1% noise factor over 0.001° to 100°/sec. Available with fixed synchronous or infinitely variable rates. Tests rate of turn in azimuth, to left or right.—*Ideal-Aerosmith, Dept. R, Div. Royal Industries, Inc.,* 3913 *Evans Ave., Cheyenne, Wyoming.*

CIRCLE 275 ON READER-SERVICE CARD

QUARTZ ACCELEROMETER

New natural quartz crystal Accelerometer features short term static response to measure high and very low frequency components of shock signals without zero shift; precise static calibration; operation over −250° to +350°C. Miniature Model 802 has 20,000-g range, 100,000-cps natural frequency; Model 812 offers high sensitivity to 100 mv/g; Model 810 operates to 50,000-g. Data Release 1201160.—*Kistler Instrument Corp., North Tonawanda, N. Y.*

CIRCLE 276 ON READER-SERVICE CARD



A FEEDBACK SERVO VALVE WITHOUT SPRINGS OR LEVERS

- Unity coupled Hydromechanical Feedback
- High Null Accuracy
- Only 2 moving parts
- Large, full opening, shear-seal orifices

This two-stage, four-way flow control valve is the only one available that provides true positional feedback without springs or levers. The first stage consists of an electrical torque motor and "shear-seal" orifice hydraulic amplifier, while the second or control stage is made up of an accurately matched spool and sleeve arrangement.

Hydromechanical unity feedback relates spool position to torque motor armature position and also nulls out effects of orifice variations due to supply pressure and temperature fluctuations. Flow force reactions are thus substantially reduced and hydraulic centering of pilot position is feasible without spring hysteresis and null shift. Large orifices prevent clogging and silting and high shear forces permit efficient operation even with highly contaminated fluids. Final null adjustments are made electrically by a balancing control at amplifier output stage.

TYPICAL CHARACTERISTICS

	Medium Flow (#6103-#6106)	High Flow (#6104)
Rated flow	to 7.5 gpm at 3000 psi valve pressure drop	to 18.0 gpm at 3000 psi valve pressure drop
Hysteresis	3% maximum total rated current	3% maximum total rated current
Supply pressure	300 to 3000 psi	300 to 4000 psi
Proof pressure	4500 psi pressure port 3000 psi return port	6000 psi pressure port 3000 psi return port
Pressure gain	First stage—500 psi per ma minimum with 3000 psi supply	First stage—500 psi per ma minimum with 3000 psi supply
Load pressure gain	8500 psi per ma minimum with 3000 psi supply	10,000 psi per ma minimum with 3000 psi supply
Temperature	−65°F to +275°F	−65°F to +275°F
Maximum Null Shift Temperature Change per 100°F	(% of rated current) 1%	1%
Supply Pressure Variation ±	2%	2%
Quiescent Current Change 20%	1%	1%
Weight	12 ounces	16 ounces

TORQUE MOTOR: Note: 6103 & 6106 Identical with exception of torque motor characteristics.

	Valve #6103	Valve #6106
Input Power	300 Milliwatts	64 Milliwatts
Rated Current	± 10 ma	± 8 ma
DC Coil Resistance (other motors also available)	3000 ohms/coil	1000 ohms/coil

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE 125 ON READER-SERVICE CARD

D-C AMPLIFIER EVALUATION *number 5 in a series*

AMPLIFIER LINEARITY

The linear d-c amplifier reproduces the input signal exactly over the full dynamic range. Negative feedback and careful component choice make possible close approaches to 100% d-c amplifier linearity.

Non-linearity is here defined as the *maximum gain deviation*, over the entire amplifier range, from an ideal straight line passing through Cartesian co-ordinate origin. The graph (Fig. 1) indicates this as well as what is known as the *best fit* method of measurement. The latter splits the error. This discussion refers to the maximum gain deviation technique. Generally speaking an amplifier with 0.02% non-linearity is considered good.

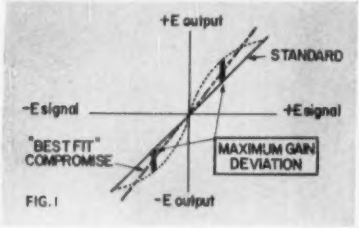


FIG. 1

D-C Amplifier Linearity Test

A null-indicating test set-up is shown in the schematic (Fig. 2). Here, an attenuator is inserted between a d-c signal and the amplifier input. This d-c signal is made equal to maximum rated output of the amplifier under test. The attenuator reduces the signal by an amount equal to the amplifier gain. As a result, under linear conditions, the amplifier output and d-c signal, prior to the attenuator, are equal. This zeros the zero-center reading 0-10 microvoltmeter connected between the amplifier output and the d-c voltage. Any meter deviation is due to amplifier non-linearity. An X-Y recorder facilitates this test. For more detail, write for BEAN 124.

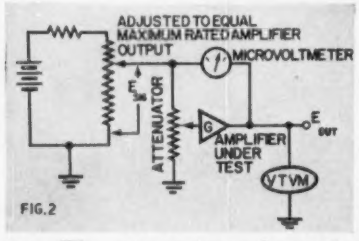


FIG. 2

AccuData III has 0.005 Per Cent Non-Linearity!

The AccuData III is the latest of Honeywell's data handling amplifiers. This all-transistor, wideband differential input, chopper-stabilized d-c amplifier has the lowest non-linearity of any amplifier in its field.

The AccuData III has single-ended as well as differential input ranges, input impedance of 2 megohms differential (20 megohms single-ended), and power output sufficient to drive the highest frequency galvanometer oscillograph to its maximum deflection. In addition to exceptional linearity, the AccuData III offers excellent drift characteristics, very low noise, and frequency response to 20 kc. Write for Bulletin BS DISA-3 to Minneapolis-Honeywell, Boston Division, Dept. 11, 1400 Soldiers Field Road, Boston 35, Massachusetts.

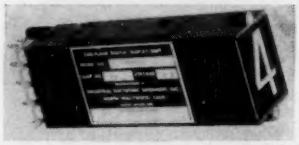
Honeywell

First in Control

SINCE 1885

CIRCLE 126 ON READER-SERVICE CARD

DIGITAL READOUT



New Series 160$_{\infty}$ In-Line Digital Readout provides lens system for larger viewing screen, 1⅝" high digits, words. Unit is 1$\frac{9}{16}$" x 2⅝" x 6½", contains 12 lamps and 12 condensing lenses, projects onto front viewing screen.—*Industrial Electronic Engineers, Inc.*, 5528 *Vineland Ave., North Hollywood, Calif.*

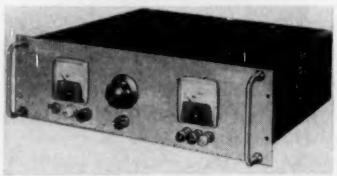
CIRCLE 277 ON READER-SERVICE CARD

METER-CONTROLLER

New Model 2547 Electronic Control Meter available with 1 or 2 control-arm circuits uses D'Arsonval movement for contactless operation with 22½ v d-c input at 10 ma. Provides continuous output signal past control setting, accurate uninterrupted full-scale indication, automatic resetting. —*International Instruments, Inc., Box 2954, New Haven 15, Conn.*

CIRCLE 278 ON READER-SERVICE CARD

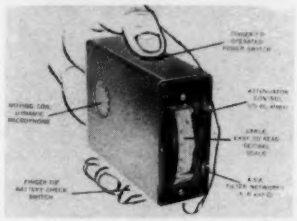
POWER SUPPLY



New Model SM 36-10M Voltage Regulated Power Supply delivers 0-36 v dc, 0-10 amp, with 0.1% regulation. Line regulation, 0.1% for 105-125 v a-c line changes; stability, 0.1% or 6 mv (whichever is greater) over 8-hr period; ripple, less than 1-mv rms; recovery time, 50 μsec.—*Kepco, Inc.*, 131-38 *Sanford Ave., Flushing 55, N. Y.*

CIRCLE 279 ON READER-SERVICE CARD

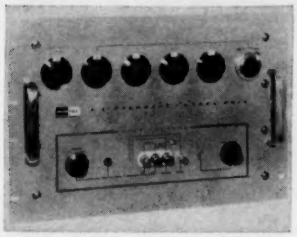
SOUND SURVEY METER



New Sound Survey Meter (Type B) weighs 1 lb, indicates sound levels from 40-125 db, has frequency response well within A.S.A. specified tolerances in 45-8000 cps spectrum. Mating transducer plugs into meter, measures relative magnitudes of vibration or structure-borne noise.—*Korfund Co., Inc., 35J Cantiague Rd., Westbury, L. I., N. Y.*

CIRCLE 280 ON READER-SERVICE CARD

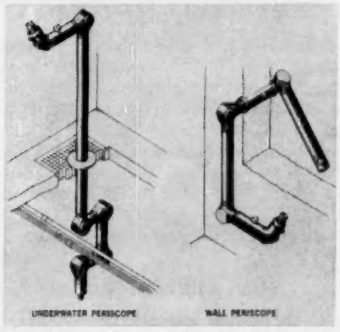
VOLTAGE STANDARD



New Model 601A AC Voltage Standard is a-c voltage source and direct calibrator of a-c measuring instruments. Features: 1-501 v supply; 60, 400, 1000-cps output frequencies; voltage accuracy to 0.1%; short term voltage stability of 0.01%; frequency accuracy of 1.0%; less than 0.3% harmonic distortion; power output 5 amps to 5 v, 25 watts above 5 v.—*Kin Tel Div., Cohu Electronics, Inc.*, 5725 *Kearny Villa Rd., Box* 623, *San Diego* 12, *Calif.*

CIRCLE 281 ON READER-SERVICE CARD

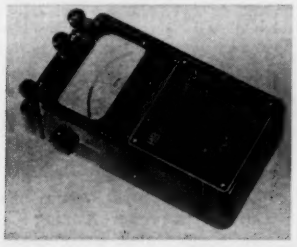
MODULAR PERISCOPE



New modular periscope can be assembled to varied lengths and configurations by using spanner wrench and screwdriver; consists of angular eyepiece telescope, lengths of relay sections, elbow fittings, and variety of viewing heads.—*Kollmorgen Corp.*, 347 *King St., Northampton, Mass.*

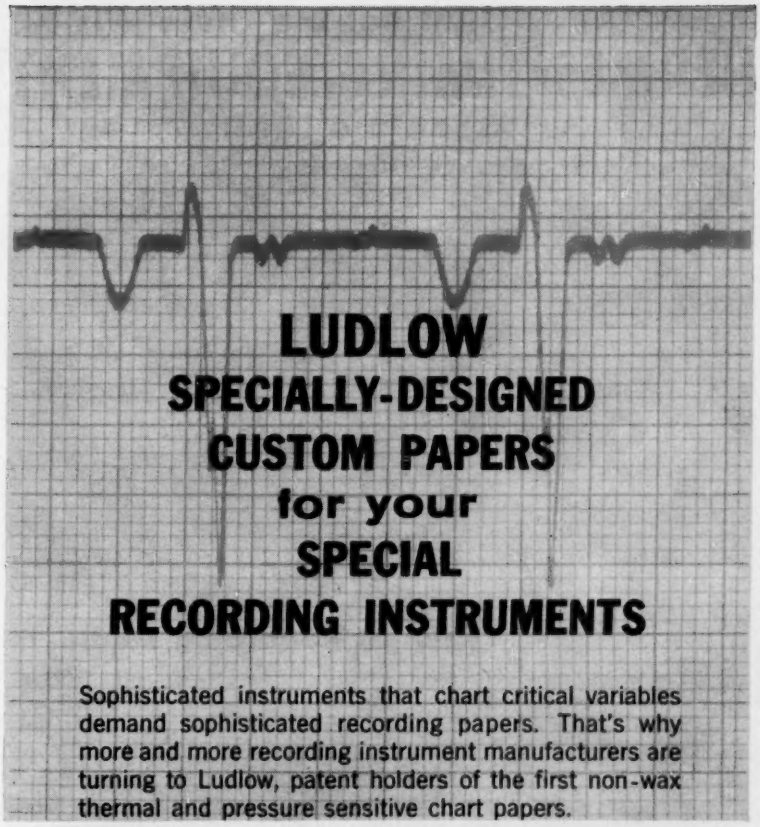
CIRCLE 282 ON READER-SERVICE CARD

IGNITION-TYPE TACHOMETER



New portable, multi-range "Tachavi" measures speed of internal combustion engines with battery ignition. Inserts in primary ignition circuit between battery and ignition coil, does not interfere with ignition process. High range for operating speeds, low for idling selected by switch.—*Epic, Inc.*, 150 *Nassau St., New York* 38, *N. Y.*

CIRCLE 283 ON READER-SERVICE CARD



LUDLOW
SPECIALLY-DESIGNED
CUSTOM PAPERS
for your
SPECIAL
RECORDING INSTRUMENTS

Sophisticated instruments that chart critical variables demand sophisticated recording papers. That's why more and more recording instrument manufacturers are turning to Ludlow, patent holders of the first non-wax thermal and pressure sensitive chart papers.

Ludlow research and engineering design will go to work for you to create to your precise specifications the exacting, ultra-sensitive recording papers required to produce ultimate performance from a fine instrument . . . records free of failures or inaccuracies. Write Dept. IC-31 for literature and samples. Include your requirements or special problems.

LUDLOW PAPERS
Needham Heights 94, Mass.
A DIVISION OF LUDLOW CORPORATION

Ludlow

CUSTOM
CHART PAPERS

CIRCLE 127 ON READER-SERVICE CARD

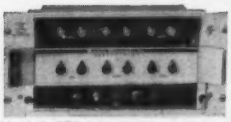
Just set the dials —

HERMES TIMING EQUIPMENT

does the rest!

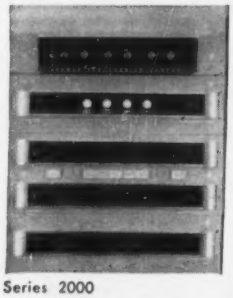
Companion Units for All Types of Recording Media

Hermes companion units provide automatic indexing during *data acquisition*, and high speed access to selected data during *data reduction*. Auxiliary equipments provide additional automatic features.



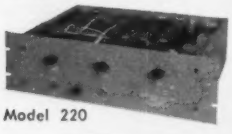
Model 270

DIGITAL TIMING GENERATOR, MODEL 270, is a solid-state instrument that generates binary coded decimal signals and records them on magnetic tape, providing a precise digital index in terms of elapsed time. Exact time in hours, minutes, and seconds is displayed in illuminated digits. A solid-state Airborne Generator, Model 206A, meeting essential requirements of MIL-E-5400, is also available.



Series 2000

UNIVERSAL MAGNETIC TAPE SEARCH UNIT, SERIES 2000, is used to control a magnetic tape transport during periods of data reduction for automatically searching the tape on the basis of time indices previously recorded. Changing from one time code to another is accomplished by changing time code detectors. All tape times are displayed in decimal regardless of tape time code format.

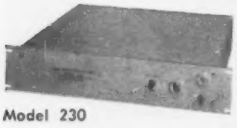


Model 220

RETARDED BIT RATE UNIT, MODEL 220, operates in conjunction with Timing Generators, Models 270 or 206A to provide a pulse-height, pulse-width signal for recording time on other than magnetic tape recorders. Operating with Tape Search Unit, Series 2000, it can reproduce previously recorded time on oscillographs.

Model 225

RUN CODE SELECTOR, MODEL 225, is used with either Model 270 or 206A Timing Generator for inserting data run code numbers, or year, month, and days in between timing words.



Model 230

TAPE SEARCH PROGRAMMER, MODEL 230, is designed for automatically programming Tape Search Unit, Series 2000, in searching for several sequential start and stop times. The input to Model 230 can be from any digital programming device such as a paper tape reader or computer.

Write for Technical Bulletins on Hermes Timing Equipment

Hermes

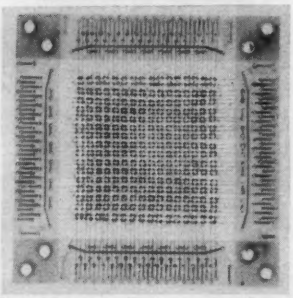
ELECTRONICS CO.

75 CAMBRIDGE PARKWAY, CAMBRIDGE 42, MASS.

A DIVISION OF Itek

CIRCLE 128 ON READER-SERVICE CARD

MEMORY FRAMES



New Memory Frames for low-cost memory systems use prefabricated printed circuit strips which minimize assembly time of custom memory frames. Four sizes (32, 48, 64, 96-wire) of strips allow ten different frame configurations. Solder-plated circuitry standard; other types available.—*Lockheed Electronics Co., Avionics and Industrial Products Div., 6201 E. Randolph St., Los Angeles 22, Calif.*

CIRCLE 284 ON READER-SERVICE CARD

CONTROL VALVES

New Series 20000 Single Seat Valves, sizes 1"-10", feature soft-seat plugs to provide tight shutoff for static pressures and pressure drops to 500 psi. Closed, plugs withstand differential pressures in excess of 1,000 psi.—*Mason-Neilan, Div. Worthington Corp., 25 Nahatan St., Norwood, Mass.*

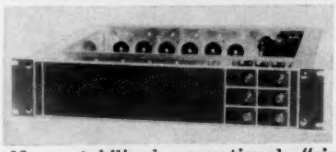
CIRCLE 285 ON READER-SERVICE CARD

VOLTAGE DIVIDER

New Model DT-72 laboratory standard, transformer-type a-c decade Voltage Divider provides certified linearities starting at ½ ppm at larger dial settings, better than 1/100 ppm at small settings. Units certified as primary ratio standards for not less than three years in normal lab environment.—*Electro Scientific Industries, 7524 S. W. Macadam Ave., Portland 19, Ore.*

CIRCLE 286 ON READER-SERVICE CARD

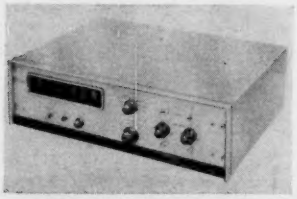
ANALOG COMPUTER MODULE



New stabilized operational "six-pack," stored program Analog Computer Building Block accommodates 6 pairs of plug-in amplifiers to provide six channels of high-gain, drift-stabilized analog computation. Programming for computer control or process and system simulation is accomplished internally by permanent wiring of circuit components on phenolic terminal board.—*Embree Electronics Corp., 993 Farmington Ave., West Hartford 7, Conn.*

CIRCLE 287 ON READER-SERVICE CARD

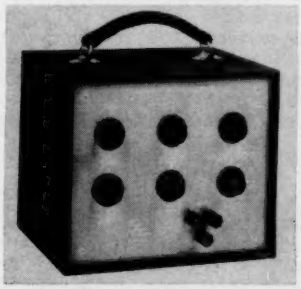
COUNTING SYSTEM



New Model 851 solid-state Megacycle Frequency-Time Digimeter consists of two identical 1-2-4-8 BCD counting trains, combined with two identical input amplifier channels and switching unit. Gated time base counter divider provides burst or damped train measurements, extends accuracy of period measurements by continuous decimal selection of period groups.—*Electronic Counters Inc.*, 155 *Eileen Way, Syosset, L. I., N. Y.*

CIRCLE 288 ON READER-SERVICE CARD

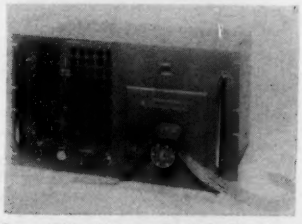
VOLTAGE SOURCE



New Model VS-111 Precision Voltage Reference Source features increased voltage range of −111.11 to +111.11 v dc to 10-mv increments, 0.025% absolute accuracy, resolution of 1 part in 10,000 plus vernier resolution. Unit is 4-decade, direct-reading, portable or rack-mounted.—*Electronic Development Corp.*, 423 *W. Broadway, Boston* 27, *Mass.*

CIRCLE 289 ON READER-SERVICE CARD

TAPE READERS

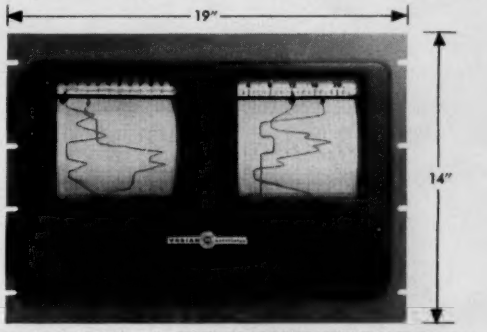


New TP 401 and 402 Perforated Tape Readers read 80 bits of information (8 levels across, 10 lines) at 6 tests/sec, locate test program at 12 ips, advance tape frame by frame on command signal (SPST switch closure.) Model TP 401 has verifier panel, shows full frame hole pattern on front of unit.—*Electronic Engineering Co. of Calif.*, 1601 *E. Chestnut Ave., Santa Ana, Calif.*

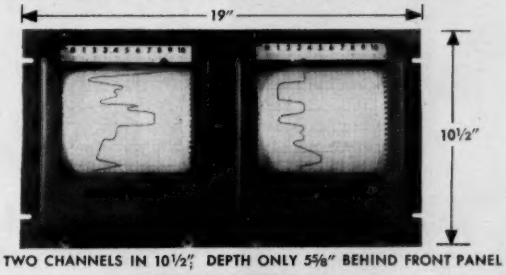
CIRCLE 290 ON READER-SERVICE CARD

VARIAN
Potentiometer
RECORDERS

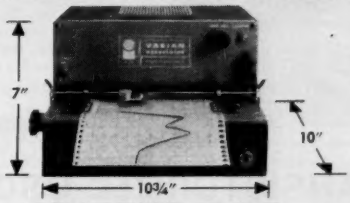
More performance in less space



G-22 FOUR CHANNELS IN 14"; DEPTH ONLY 11½" BEHIND FRONT PANEL



G-11A TWO CHANNELS IN 10½"; DEPTH ONLY 5⅝" BEHIND FRONT PANEL



G-10 ONE CHANNEL <½ CU. FT.

THREE COMPACT CHOICES

Using one quarter the space of many comparable potentiometer recorders, the Varian family packs exceptional function into very little space. Interchangeable input chassis accommodate full-scale signal voltages from 10mv to 500v d.c., temperatures from −200°C to +1500°C, and 1mA current recording. The Varian recorders have 1% accuracy, ⅛%-of-span sensitivity, 1 or 2½ second balancing time, full-span zero adjust, Zener diode or mercury cell reference. A selection of chart speeds from ⅛"/hour to 16"/minute lets you pick the time resolution you need.

In addition to being rack-mountable, the G-22 and G-11A are portable for use in many locations. A wide range of accessories—such as retransmitting slidewires, alarm contacts and event markers—helps broaden the outstanding functional versatility outlined above. Chances are a Varian recorder can serve your need. Write Instrument Division for detailed specifications.

VARIAN associates
PALO ALTO 27, CALIFORNIA

NMR & EPR SPECTROMETERS, MAGNETS, FLUXMETERS, GRAPHIC RECORDERS, MAGNETOMETERS, MICROWAVE TUBES, MICROWAVE SYSTEM COMPONENTS, HIGH VACUUM EQUIPMENT, LINEAR ACCELERATORS, RESEARCH AND DEVELOPMENT SERVICES

CIRCLE 129 ON READER-SERVICE CARD

For the Traveling Engineer...
TYPE 321 OSCILLOSCOPE
The Type 321 plus average baggage is normally within 40-pound allowance. Its size is within usual limits for items carried aboard commercial airliners.

Photographed at Portland International Airport, courtesy of United Air Lines.

NEW TRANSISTORIZED OSCILLOSCOPE

Tektronix Type 321 This portable electronic tool operates anywhere—on its self-contained batteries, on external 11.5 to 35 volts dc, and on 117 or 234 volts from 50 to 800 cycles. Its dc-to-5 mc frequency response and compatible companion features are adequate for field measurements and waveform observations in complex electronic equipment.

The Type 321 weighs only 13½ pounds without batteries—less than 17 pounds with rechargeable cells. It measures only 8¾″ high, 5¼″ wide, 16″ deep, has built-in battery charger. Your Tektronix Field Engineer would like to demonstrate this convenient oscilloscope in your applications. Call him today.

A four-page folder covering complete specifications of the Type 321 is available from your Tektronix Field Office.

- Type 321 without batteries $785.00
- Rechargeable 4.0 ampere-hour battery set 61.00
- Rechargeable 2.5 ampere-hour battery set 36.50

(prices f.o.b. factory)

Tektronix, Inc.

P.O. Box 500 • Beaverton, Oregon • Phone Mitchell 4-0161 • TWX—BEAV 311 • Cable: TEKTRONIX

TEKTRONIX FIELD OFFICES: Albuquerque, N. Mex. • Atlanta, Ga. • Baltimore (Towson, Md.) • Boston (Lexington, Mass.) • Buffalo, N.Y. • Chicago (Park Ridge, Ill.) • Cleveland, Ohio • Dallas, Texas • Dayton, Ohio • Denver, Colo. • Detroit (Lathrup Village, Mich.) • Endicott (Endwell, N.Y.) • Greensboro, N.C. • Houston, Texas • Indianapolis, Ind. • Kansas City (Mission, Kan.) • Los Angeles, Calif. Area (East L.A. • Encino • West L.A.) • Minneapolis, Minn. • New York City Area (Albertson, L.I., N.Y. • Stamford, Conn. • Union, N.J.) • Orlando, Fla. • Philadelphia, Pa. • Phoenix (Scottsdale, Ariz.) • Poughkeepsie, N.Y. • San Diego, Calif. • San Francisco (Palo Alto, Calif.) • St. Petersburg, Fla. • Syracuse, N.Y. • Toronto (Willowdale, Ont.), Canada • Washington, D.C. (Annandale, Va.)

TEKTRONIX ENGINEERING REPRESENTATIVES: Hawthorne Electronics, Portland, Oregon • Seattle, Washington. Tektronix is represented in twenty overseas countries by qualified engineering organizations.

In Europe please write Tektronix Inc., Victoria Ave., St. Sampsons, Guernsey C.I., for the address of the Tektronix Representative in your country.

CIRCLE 130 ON READER-SERVICE CARD

DATA ACQUISITION SYSTEM

New Single Channel Data Acquisition System DAS-22 consists of analog-to-digital converter, programmer and high speed punch; reads transducer outputs from ±0.001 to±1000 volts (in 4 ranges) directly onto punched tape in 1-2-4-8 binary code. Accuracy of ±0.1% of full scale ±½ least significant count at punching rate of 60 numbers/sec or 15 polarity-coded 3-digit values/sec. With punch-off, converter can be used as DVM with sampling rate of 100 conversions/sec.—*Electronic Controls Inc., Magee Ave., Stamford, Conn.*

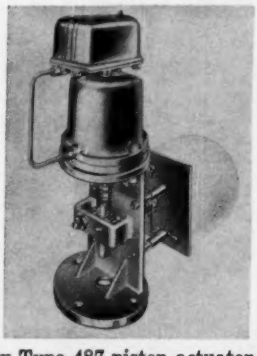
CIRCLE 291 ON READER-SERVICE CARD

WELDING RECORDER

New Weld-Record provides automatic time-study data on all electric welding operations. Time-printed rolls feed at 4″/hr; ball-point stylus draws graph lines showing On and OFF time. Tape accessible for operator to note reason for downtime. Time Totalizer totals productive time (to 0.1 min) for any given period.—*Weld-Record Corp., 657 Broadway, New York 12, N. Y.*

CIRCLE 292 ON READER-SERVICE CARD

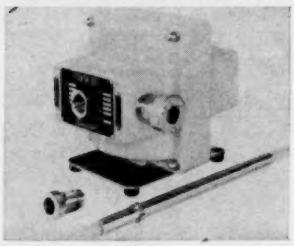
VALVE ACTUATOR



New Type 487 piston actuator combines with rack and pinion to convert linear motion to rotary motion. Actuator positions rheostat in response to pneumatic signal, produces 185 in-lb torque with 40-psig air supply. At full piston rod travel (4″) rheostat rotates 360° on 1:1 ratio.—*Fisher Governor Co., Box 307, Marshalltown, Iowa.*

CIRCLE 293 ON READER-SERVICE CARD

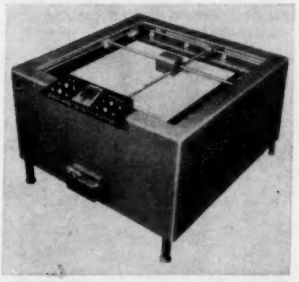
MAGNETIC FLOWMETER



New Flowmeter features removable flow tube for convenient sterilization; measures flows of pharmaceuticals, film emulsions, blood, etc. Liquid flowing through magnetic field generates voltage proportional to rate of flow. Metering accuracy ±1% full scale; repeatability within ±0.5%; flow range, 0-1 liter/min or higher.—*Foxboro Co., Foxboro, Mass.*

CIRCLE 294 ON READER-SERVICE CARD

30″ X 30″ PLOTTER



New 30" x 30" X-Y solid-state Plotter eliminates servo mechanisms, is accurate to 0.05% full scale, repeats exactly from any direction. Input from cards, punched tape or keyboard; slewing speed to 20 ips.—*Gerber Scientific Instrument Co., 89 Spruce St., Hartford, Conn.*

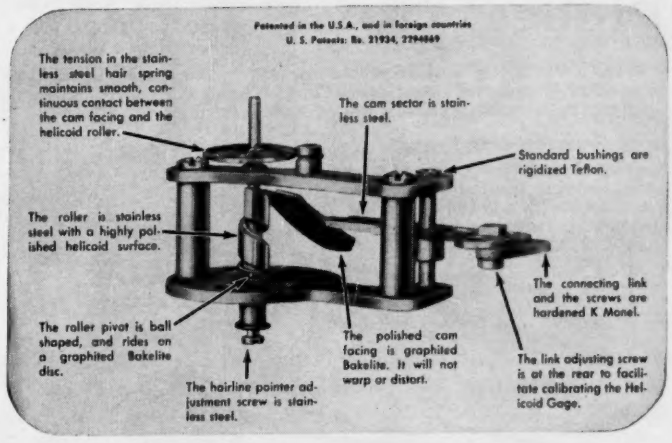
CIRCLE 295 ON READER-SERVICE CARD

TELEMETRY DIVERSITY COMBINERS

New Telemetry Diversity Combiners OR-DD/2, OR-DD/3 and OR-DD/4 have 2, 3 and 4 channels, respectively. Signal-to-noise improvements as high as 6 db for 4-channel combiner (shown), which operates over input signal dynamic changes beyond 80 db. For use at multiple receiver telemetry stations, combiner operates in post-detection, optimum-diversity ratio-squared combination mode.—*Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J.*

CIRCLE 296 ON READER-SERVICE CARD

ACCO Helicoid Gage U.S.A.


Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2794869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy... on the toughest jobs*

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details

Ask for Catalog DH-65

HELICOID GAGES

ACCO

Helicoid Gage Division • American Chain & Cable Company, Inc.

929-B Connecticut Ave., Bridgeport 2, Conn.

CIRCLE 131 ON READER-SERVICE CARD

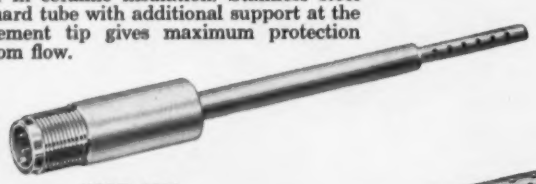
REC's.....

Precision Temperature Probes.....at off the shelf prices!

Want low cost temperature probes on short notice – without sacrifice in quality? Rosemount Engineering Company now offers high-performance platinum resistance temperature sensors from stock.

MODEL 179A

Sensing element fully supported, mounted in ceramic insulation. Stainless steel guard tube with additional support at the element tip gives maximum protection from flow.



MODEL 179A

MODEL 152T

MODEL 152T

Sensing element supported by a light cage and exposed to working fluid to give extremely fast response in fluids which are not electrical conductors. Element protected by stainless steel guard tube with additional support at the element tip.

Fourteen stem lengths and 6 different fittings of each model available. These immersion probes have wide application in research, development and industrial process controls. Recommended for use in most hydrocarbons, gaseous or liquid air, oxygen, nitrogen, hydrogen or helium. Sensing elements, of precision platinum, are calibrated at liquid helium point and the ice point. General specifications:

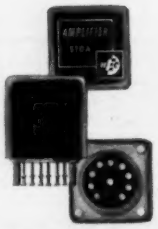
- Temperature Range – from –435°F to 500°F
- Stability – Stable within 0.20°F at 32°F
- Pressure – 6,000 psi maximum
- Element Length – from 1⅛" to 2¾", in ⅛" increments
- Time Constant – 152T – 0.2 seconds } Dow Corning No. 200
  179A – 0.5 seconds } 1.5 CTSK Oil
- Resistance at 32°F – 152T – 200 ohms
  179A – 500 ohms

For additional information write for advance bulletin number 5603.

Plus Circuit Modules

Rosemount also offers a series of preassembled circuit components, featuring small size and durability. Built to meet environmental requirements of MIL-E-5272 and MIL-E-8189.

- General purpose amplifier, Model 510A, 40 db voltage gain minimum, 10 cps to 100,000 cps, –55°C to 125°C.
- High impedance input amplifier, Model 511A, 20 db power gain, input impedance greater than 1 x 10^6 ohms, 10 cps to 50,000 cps, –55°C to 125°C.
- Power supply, Model 531A, 117 volts, 400 cps; 20 volt DC regulated, 10 milliamperes, 0.1 percent ripple, –55°C to 125°C.
- Rectifier-filter, Model 532A, diodes and RC filter for two full wave DC supplies. Rated 30 volts DC each at 0.1 percent ripple, –55°C to 125°C.



(Size 1 x 1 x 1 Inch)

For additional information write for advance bulletin 46028.

ROSEMOUNT ENGINEERING COMPANY

4900 West 78th Street, Minneapolis 24, Minn.

CIRCLE 132 ON READER-SERVICE CARD

PLASTIC-BODY VALVE

New "BP" plastic bar valve stock bodies for use with highly corrosive fluids to 125 psi are available in single-port globe style, ½", ¾" and 1" sizes, screwed ends. Polyvinyl chloride can be provided with socket ends for solvent welding. PVC and Penton materials can be furnished with end connections suitable for mounting between pipeline flanges. Valve plug is port-guided Micro-Flute percentage type in metal or plastic; 1-3 flutes provided to obtain different capacities for same size orifice. Bulletin E-73.—*Fisher Governor Co., Box 307, Marshalltown, Iowa.*

CIRCLE 297 ON READER-SERVICE CARD

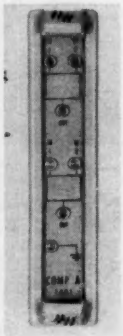
ANALOG-EVENT RECORDER

New Analog-Event Recorder combines two functions in one graphic instrument. Six pens record events while central analog pen records effect of events on given quantity.—*Esterline-Angus Instrument Co., 1201 Main St., Speedway, Ind.*

CIRCLE 298 ON READER-SERVICE CARD

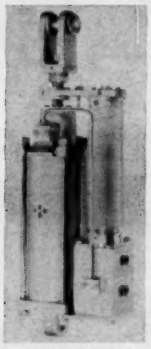
HALF-ADDER MODULE

New Model 1281 Data Bloc half-adder module is for digital system applications requiring comparison of outputs of flip-flops and registers to perform arithmetic operations. Two identical circuits, each performs comparison function to satisfy Boolean equations $A\overline{B} + \overline{A}B = C$, and $AB + \overline{A}\overline{B} = \overline{C}$. —*Harvey-Wells Electronics, Inc., 14 Huron Dr., Natick, Mass.*



CIRCLE 299 ON READER-SERVICE CARD

POWER POSITIONER



New pneumatic Power Positioner controls unbalanced loads to 150 lb with ±1% accuracy. Positioning cylinder has 2-½" bore, 5" stroke, operates in ambient temps to 170°F. With 100-lb air supply and no load, unit requires 1.5 sec for full stroke movement.—*Controls Div., Hagan Chemicals & Controls, Inc., Hagan Center, Pittsburgh 30, Pa.*

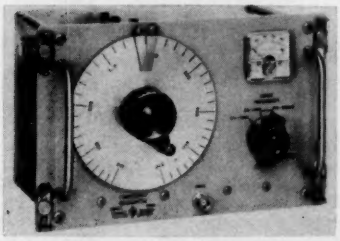
CIRCLE 300 ON READER-SERVICE CARD

TEMP-SENSING HEAD

New Infrared Optical Head senses surface temps from 120° to 1200°F connects to Williamson Radiometer or modified recorder for experimental work, links to automatic controls without disturbing position. Field of view is 1/30 of working distance (approx 30"). Stability ±2°; accuracy ±2° from 100° to 300°F; system works down to 2 microns.—*Williamson Development Co., Inc., 317 Main St., W. Concord, Mass.*

CIRCLE 301 ON READER-SERVICE CARD

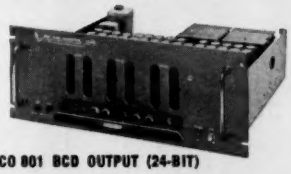
500-MC COUNTERS



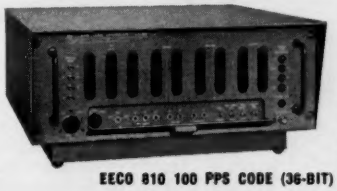
New Model 525C Frequency Converter unit increases capability of Model 524B, C or D counters to measure frequencies between 100 and 510 Mc with 100-mv sensitivity, to amplify signals between 50 kc and 10.1 Mc with 20-mv sensitivity. Model 524 has stability of 5 parts in 10^8 per week.—*Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif.*

CIRCLE 302 ON READER-SERVICE CARD

TIME TEAM



EECO 801 BCD OUTPUT (24-BIT)



EECO 810 100 PPS CODE (36-BIT)

SEND FOR TIME CODE GENERATOR FILE 301

HOW EECO'S ALL-STAR LINEUP OF TIME CODE GENERATORS WINS ON EVERY POINT

Look at these unparalleled advantages offered by EECO Time Code Generators! Frequency stability, 3 parts in 10^8, based on extremely stable crystal oscillator. 100% plug-in circuits to keep generator working for you day in and day out. Emitter-follower low-impedance outputs for long-distance transmission. Wider operating-temperature stability. Operable from aircraft power. Provision for external frequency standard. Auxiliary pulse rates.

Model Number	Serial Code Format	Time Indication	Code Frame Length (SEC)	Code Scan Rates (PPS)	Code Carrier Frequency (CPS)	Price (f.o.b. Santa Ana)
EECO 801	24-Bit, 24-hour, BCD	hr. min. sec.	1	25, 50, 100	1000	$7500
EECO 802	17-Bit, 24-hour, Binary (Eglin AFB)	hr. min. sec.	1	20, 100	1000	$7000
	13-Bit, 24-hour, Binary (Patrick AFB)	hr. min. ¼ min.	15	1	1000	
EECO 802M1	17-Bit, 24-hour, Binary (Atlantic Missile Range)	hr. min. sec.	1	100	1000	$7000
EECO 802M2	17-Bit, 24-hour, Binary (Atlantic Missile Range)	hr. min. sec.	1	20, 100	1000	$7000
			20	1		
EECO 803	20-Bit, 24-hour, BCD	hr. min. sec.	1	25	250	$7500
EECO 804	20-Bit, 24-hour, BCD	hr. min. sec.	1	25	100 W/1000	$7925
EECO 810	36-Bit, 365-day, BCD	day hr. min. sec	1	100	1000	$10,100
EECO 810M1	23-Bit, 365-day, BCD (IRIG Member C Format Modified)		60	2	1000	$10,100

Electronic Engineering Company *of California*

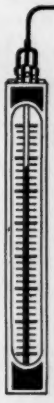
1601 East Chestnut Avenue • Santa Ana, California • Kimberly 7-5501 • TWX: S ANA 5263

EE 1-27

CIRCLE 133 ON READER-SERVICE CARD

TANK-O-METER

FOR MEASURING TANK CONTENTS ANY DISTANCE AWAY



TANK MAY BE BURIED, ELEVATED, OPEN, CLOSED, VENTED OR UNDER PRESSURE OR VACUUM

SEND FOR BULLETINS

Also gauges for:
Barometric Pressure (Mercury Column)
Absolute Pressure (Mercury Column)
Pressure and Vacuum
Differential Pressure
Inclined Manometers for draft, pressure or differential pressure.

UEHLING INSTRUMENT CO. 470 GETTY AVE., PATERSON, N. J.

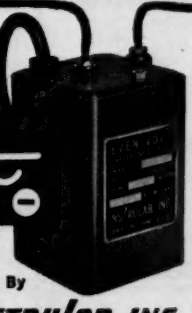
CIRCLE 134 ON READER-SERVICE CARD

INSTRULAB'S

Temperature Compensated

evenvolt

Constant Voltage Unit



Replaces Batteries and All Standardizing Components Including Standard Cell In

POTENTIOMETERS

• CONTROLLERS • INDICATORS • RECORDERS

Mfg. By **INSTRULAB, INC.**

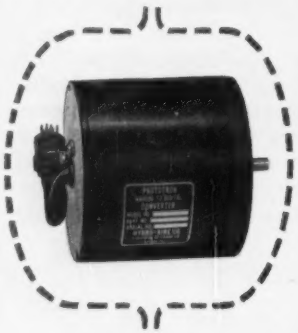
1205 Lamar Street
Dayton 4, Ohio
Phone BA 3-2241

Outstanding FEATURES

- Eliminates batteries ...errors due to battery exhaustion
- Reliable construction...from quality components, long, trouble-free service
- A Precise voltage regulator . . . max. ±.04% for ±20% voltage variation
- Quickly Installed... Fits present instrument battery space.
- No Tubes to replace

CIRCLE 135 ON READER-SERVICE CARD

PHOTOTRON



FIRST IN NEW LINE OF ANALOG TO DIGITAL CONVERSION PRODUCTS FROM HYDRO-AIRE

This highly versatile basic transducer offers incremental conversion of shaft angle to digital measurement. Available in seven models, its maximum permissible speeds range from 15,000 rpm at 128 counts per revolution to 1,250 rpm at 2,048 counts, with sample rates ranging to 45,000 counts per second.

Applications for the Hydro-Aire Phototron include analog to digital shaft converters, precision analog servo with digital readout, data reduction equipment, tachometers, and precision measurement and control.

Detailed specifications are available on request. Related products soon to be available from Hydro-Aire, a member of the Crane Co. Systems and Controls Group, will include associated power supplies and binary and digital counters.

HYDRO-AIRE

3000 WINONA AVE., BURBANK, CALIF.

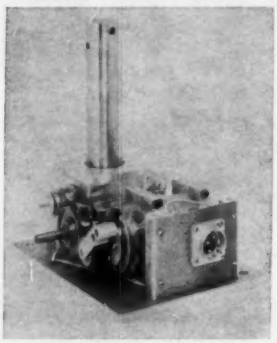
DIVISION OF CRANE CO.

Solid-state devices include time delay devices, voltage regulators, power supplies, inverters.

CIRCLE 136 ON READER-SERVICE CARD

New Products—IRE

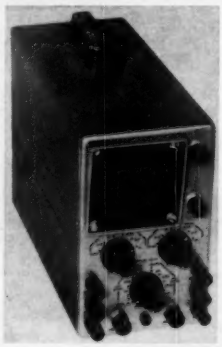
MISSILE COMPONENT



New 8-msec response electric Servo-actuator for control of flight surfaces of missiles allows 50% weight saving over hydraulic systems. Each flight control surface directly connected to its own actuator. Also to be shown: new multivoltage output static power supply for missile application with voltage held to ±0.5%; frequency changer which keeps air-launched, infra-red missile locked onto target; temp-compensated motor tachometer for missile guidance; resolver which sets Polaris guidance system on course with 20-sec accuracy.—*American Electronics, Inc.*, 1725 *W. 6 St., Los Angeles* 17, *Calif.*

CIRCLE 303 ON READER-SERVICE CARD

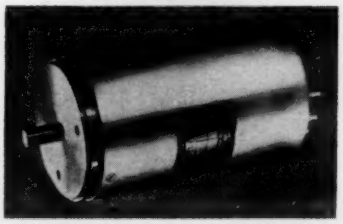
OSCILLOSCOPE, RELAYS



New Heath Model I0-10 "Space Saver" 3" d-c oscilloscope features identical vertical and horizontal dc-coupled amplifiers with low relative phase shift characteristics and transformer-operated power supply. Also to be shown: new Model 1073 Mag-Trak Relay which provides positive reliable contact even when contact points have become contaminated; Transicoil synchro with stainless steel housing for improved temp stability without increased weight.—*Weston Instruments Div., Daystrom, Inc.*, 614 *Frelinghuysen Ave., Newark* 12, *N. J.*

CIRCLE 304 ON READER-SERVICE CARD

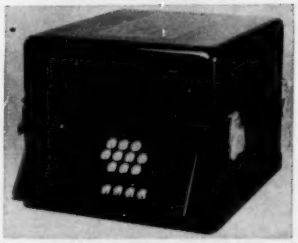
POTENTIOMETERS



New precision Potentiometers for a-c excited circuits have high input impedance, low output impedance, reducing quadrature and loading effects. Also being shown: new 1 1/16" dia ceramic/metal single-turn potentiometer, cermet resistance elements, spec turns-counting dials, and 2"-dia sine/cosine pot; new panel meters in square and rectangular models.—*Helipot Div., Beckman, Instruments, Inc.*, 2500 *Fullerton Rd., Fullerton, Calif.*

CIRCLE 305 ON READER-SERVICE CARD

POWER SUPPLY



New precision 25-va a-c Power Supply has output frequency of 350-450 cps; amplitude and frequency stability, 0.1%; regulation, 1% 0-full load; output, variable 0-130 v.—*Industrial Test Equipment Co.*, 55 *E.* 11 *St., New York* 3, *N. Y.*

CIRCLE 306 ON READER-SERVICE CARD

CATHODE RAY TUBE

New Type SC-3076 5" industrial "Bonded Shield" cathode ray tube features permanent built-in reference scale on integral reflection-free safety panel. Offers maximum image visibility, wide angle viewing, simplified mounting, self-contained writing surface. Also, new multi-trace Type SC-3061 10" tube features astigmatism control electrode.—*Sylvania Electric Products, Inc.*, 730 *Third Ave., New York* 17, *N. Y.*

CIRCLE 307 ON READER-SERVICE CARD

(*Cont. on Page* 535)

"Just what the doctor ordered!"

TABER TRANSISTORIZED AMPLIFIER SYSTEMS

You're the doctor when it comes to TABER TRANSISTORIZED AMPLIFIER SYSTEMS. You name it and we'll ship it to you from stock or we'll custom design and produce it for you if you desire quantities. However, you'll probably find exactly what you want when you see our complete line folder.

Write for Complete Line Folder

Taber

TABER INSTRUMENT CORPORATION

"Where the Accent is on Accuracy & Reliability"

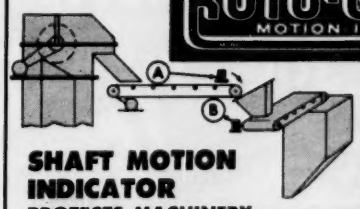
Section 243 107 Goundry St. North Tonawanda, N. Y.

Telephone: NX 3-8900 • TWX-TON 277

CIRCLE 137 ON READER-SERVICE CARD

ROTO-GUARD

MOTION INDICATOR



SHAFT MOTION INDICATOR

PROTECTS MACHINERY BY INDICATING STOPPAGE DUE TO OVERLOADING OR MALFUNCTION

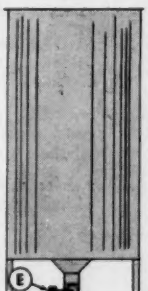
A and B: On end return idlers, warn if conveyor should break, slow or stop.

C: On boot pulley, signals slowdown, stoppage, slippage due to overload, boot pulley out of adjustment. Helps prevent fires.

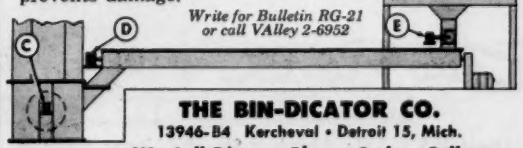
D: On screw conveyor, warns of slowdown due to overloading. Prevents damage.

E: On rotary feeder, warns of slowdown; prevents plugging damage.

Roto-Guards can be wired into interlock system; stoppage of one component automatically stops others; prevents damage.



Write for Bulletin RG-21 or call VAlley 2-6952



THE BIN-DICATOR CO.

13946-B4 Kercheval • Detroit 15, Mich.

We Sell Direct • Phone Orders Collect

CIRCLE 138 ON READER-SERVICE CARD

A. D. JONES OPTICAL WORKS

2400 MASSACHUSETTS AVENUE

CAMBRIDGE 40 MASSACHUSETTS

TRowbridge 6-3368—3369

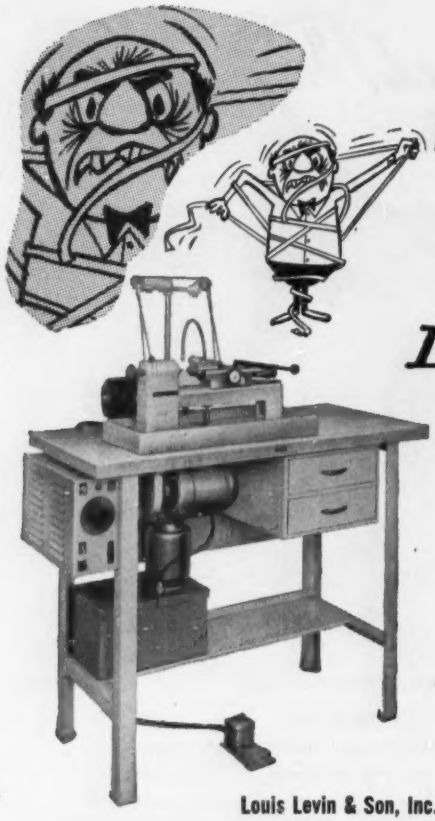
A LIST OF MATERIALS WE FABRICATE USED IN OPTICS AND ELECTRONICS

SAWING GRINDING POLISHING DRILLING

ALUM
ALUMINA
ALUMINUM
ANTHRACENE
ARSENIC TRISULPHIDE
BARIUM TITANATE
BISMUTH
BRASS
CARBORUNDUM
CERAMIC
COBALT FERRITE
COPPER
*CORNING 707
*CORNING 7052
COPROUS BROMIDE
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GALLIUM ARSENIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM
MAGNETIC PLUMBITE
MELAMINE FIBER GLASS
MICA, SYNTHETIC
NICKEL OXIDE
PLATINUM
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
**SODIUM CHLORIDE
**STEEL
STRONTIUM TITANATE
TEFLON
TITANIUM DIOXIDE
*VYCOR
*X-RAY LEAD GLASS
ALL TYPES KNOWN GLASS

* Carried in stock
** Purchased for orders

CIRCLE 139 ON READER-SERVICE CARD



ARE YOU PROPERLY GEARED FOR

MINIATURIZATION?

DRILL MICRO-HOLES

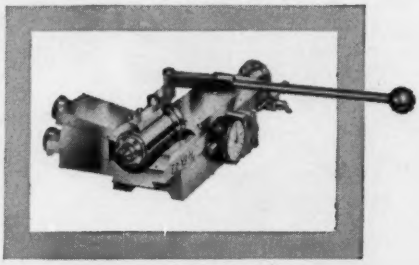
DOWN TO .0016"* with SPEED & ACCURACY

LEVIN ® MICRO-DRILLING MACHINE

Designed for the most precise drilling of small holes. The drilling spindle, as well as the head stock spindle, revolves and thus the maximum straightness and concentricity are assured. The feed is so arranged that it does not depend on the operator's sense of feel and the smallest drills may be safely used.

* Smallest commercial drill available.

For full details of Drilling Machine and Instrument Lathes send for catalog T.



Louis Levin & Son, Inc., 3573 Hayden Ave., Culver City, Calif.

CIRCLE 140 ON READER-SERVICE CARD

PHILADELPHIA

THERMAL CONTROLS AND THERMOMETERS

Specify! THE BEST!

A half century of experience is back of every instrument we make. You get assured accuracy and long dependable performance when you specify "Philadelphia." Our specialized staff will be glad to discuss your problem in our field.

SEND FOR CATALOG 110

Since 1905

PHILADELPHIA THERMOMETER CO.

4401 N. Sixth St. • Philadelphia 40, Pa.

CIRCLE 141 ON READER-SERVICE CARD

INSULATED WIRE

that will withstand 3000°F

AERO PAK

Electrical Conductors
Thermocouple Wire
Miniature Heating Elements

AERO PAK

Thermocouples made to your specifications
Send for Bulletin 3.8A

- Available in outside diameters of .025 to .313
- One or more wires insulated from metallic sheath by a ceramic oxide.
- AerOPak can be bent and weldments performed without loss of insulation.
- Available in a variety of metal sheath materials, insulations and wires.

Ask for a new **revised** issue of Bulletin 4.

VSMF—Reel F

Aero Research

INSTRUMENT COMPANY, INC.

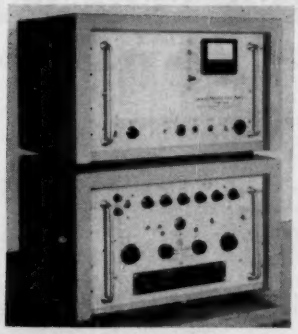
Dept. ICS, 315 No. Aberdeen Street, Chicago 7, Illinois

Sales Representatives throughout the United States and Canada

CIRCLE 142 ON READER-SERVICE CARD

IRE New Products Cont. from 532

AC/DC POWER SUPPLY



New Model 2120 AC-DC Precision Power Supply provides emf outputs from 0.1500 v and current from 0-30 amp. Ac output ranges in frequency from 50 cps-20 kc. Fixed frequency settings of 50 to 2400 cps provided, also continuous frequency coverage.—*Radio Frequency Laboratories, Inc., Powerville Rd., Boonton (Twp.), N. J.*

CIRCLE 308 ON READER-SERVICE CARD

RECORDER/REPRODUCER

New G-100 Instrumentation Recorder/Reproducer has bandpass at 60 ips of 200 cps to 300 kc with analog modules and dc to 20 kc with FM modules. Features wide dynamic range, all-transistorized electronics, 6 standard speeds from 3¾ to 60 ips, built-in signal monitoring switcher and calibration. Also, new CM-100 Video Band Recorder/Reproducer for predetection recording has bandwidth extended to 1.2 mc (20% increase), converts to 14 tracks to accommodate 14 tracks of information on 1" tape.—*Mincom Div., Minnesota Mining and Manufacturing Co., 2049 S. Barrington Ave., Los Angeles 25, Calif.*

CIRCLE 309 ON READER-SERVICE CARD

RESISTORS, POTENTIOMETERS

New molded deposited-carbon resistor meets RC-07 size requirements, operates as 1/10-w resistor at 125°C, ¼-w unit at 70°C; 200 v max with standard range of 10 ohms to 300K. New epoxy-coated resistors have resistance of 10 ohms to 499K (⅛-w unit), 10 ohms to 2 Meg (¼-w unit). Also being shown: new epoxy-coated metal film resistors in ⅛, ¼ and ½ watt sizes; 1⅞" and 1" Revodex dials; ⅞"-dia multi-turn potentiometers; 2-w axial lead power wire-wound resistor; Circuitrim 100 and 200 precision potentiometers.—*International Resistance Co., 401 N. Broad St., Phila. 8, Pa.*

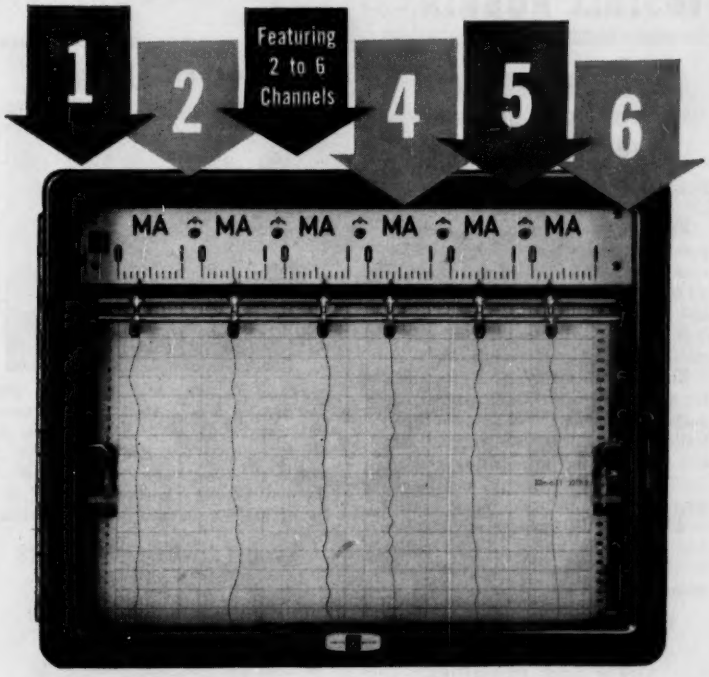
CIRCLE 310 ON READER-SERVICE CARD

MULTICHANNEL

RECTILINEAR

RECORDERS

Variable-width channel operation provides simultaneous recording of two to six different signal functions on a single chart. Curtiss-Wright has the only rectilinear recorder available with this combination of features. Simple operation, versatility, dependable performance and compactness assure optimum flexibility for a wide range of applications.



Advantages and Features:

Versatility—Wide choice of ranges, chart drives, and speeds. AC and DC Movements.

Accuracy—±1% of full scale for DC movements. Sensitivity down to 250 μa DC. May be extended by optional DC amplifier.

Optimum Reading Ease—Rectilinear ink or inkless recording provides undistorted signal traces.

Utmost Reliability — Inherently self-shielding, permanent-magnet, moving-coil movements eliminate tubes, choppers, motors and slidewires.

Ruggedness — Shockproof suspension with dustproof, splashproof and anti-magnetic construction.

Standard Size Model
1, 2 or 3 channels
Portable, flush mount or projection switchboard and wall mounting
Weight: 19 lbs.
Size: 7½" x 9¹³⁄₁₆" high x 7⅞" deep

Double Size Model
2, 3, 4, 5 or 6 channels
Portable, flush mount or projection switchboard and wall mounting
Weight: 26 lbs.
Size: 12¾" x 9¹³⁄₁₆" high x 8¾" deep

Send for catalog or phone swinburne 9-0500.

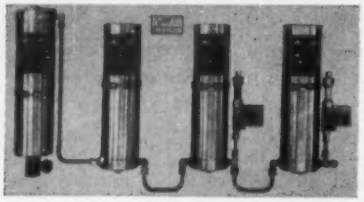
CURTISS WRIGHT

Princeton Division CORPORATION Princeton, New Jersey

In CANADA: Canadian Curtiss-Wright Ltd. • 42 Westminster Avenue, North • Montreal 28, P. Q., Canada

CIRCLE 143 ON READER-SERVICE CARD

When water or oil in gases cannot be tolerated . . .



INSTALL ROBBINS

dehydration equipment

Robbins Aviation offers you both disposable cartridge type and refrigeration type dehydration systems for practically all types of gases . . . equipment designed and built to rigid quality control standards to give you maximum satisfaction in efficient trouble-free performance.

Robbins equipment is used extensively for aircraft pneumatic systems, test laboratory equipment, mobile compressor trailers, hydraulic system purging, missile charging and pressurizing systems, for instrument, laboratory, and factory air, controlled atmospheres for brazing and heat-treating furnaces, etc. Mechanical filters, drier and purifier chambers, refillable and disposable cartridges, dewpoint indicators also available.

Fast, positive, economical removal of water or oil vapor and impurities

Pressures to	12,000 PSI
Safety Factor	4 to 1
Dewpoints to	−100°F
Oil Vapor Removed to . . . as low as 0.3 ppm/w	

Write today for complete information!

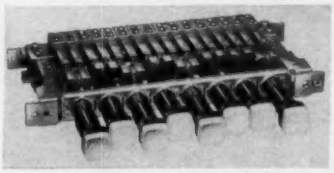
ROBBINS Aviation, Inc.

Manufacturers of high quality valves and dehydration equipment

2350 E. 38th St., Los Angeles 58, Calif.
LUdlow 9-5221

CIRCLE 144 ON READER-SERVICE CARD

ILLUMINATED SWITCHES



New Series 21000 Multi-Switch features square buttons with side and front illumination, large identification area. Buttons key in any of four planes for horizontal or vertical mounting of switch frame. Available in 6v, 28v and Neon (115v ac). Lock-up bar optional. Also to be shown: new Series 23000 Time-Toggle Switches and Series 1500 and 15000L non-lock and push-to-lock switches.—*Switchcraft, Inc., 5555 N. Elston Ave., Chicago 30, Ill.*

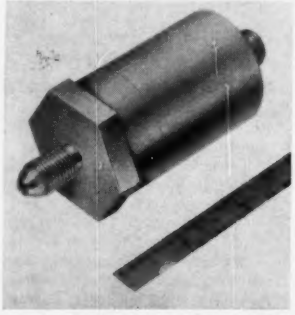
CIRCLE 311 ON READER-SERVICE CARD

PANEL METERS

New Prince a-c and d-c Panel Meters in 2½", 3½" and 4" models feature EZ-Read dial, one-screw Loc-Quik mount, accuracy of ±2% full scale.—*Yokogawa Electric Works, Inc., 40 Worth St., New York 13, N. Y.*

CIRCLE 312 ON READER-SERVICE CARD

DIGITAL TRANSDUCERS



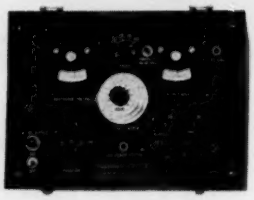
New solid-state 2"-dia x 2" Digital Transducers sense many different sources of energy, deliver digital signal proportional to amount of energy monitored. Signal pre-calibrates to correspond to parameter being measured without need for zero supression. Conversion linearity within ±0.5%, repeatability within 0.2%. Impervious to temp range −55° to +85°C, vibration range 10-2000 cycles, 15 G.—*DeJur Amsco Corp., Northern Blvd at 45 St., Long Island City 1, N. Y.*

CIRCLE 313 ON READER-SERVICE CARD

TEST EQUIPMENT BY... tensor

PORTABLE AC-DC REFERENCE SOURCE

MODEL 5890 $495



Here is a completely self contained standard for meter calibration. Accuracy is held to .25% of set voltage. Supplies are regulated and one watt of power is available from 0 to 100 volts.

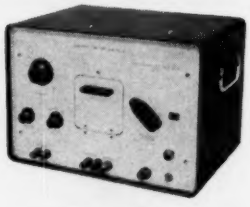
INCREMENTAL ANALYZER

MODEL 5880 $250

This general purpose input adapter for high impedence recorders is used to allow the display of any voltage, current, resistance or temperature measurable on the units VOM. Increments of any part of the range may be expanded to full scale readout on a recorder or sensitive DC millivoltmeter.

ARBITRARY FUNCTION GENERATOR

MODEL 5846 $495



Covering the frequency range of .001 to 10 cycles per second, waveforms are programmed by shaped cams. In addition to the selected function, a square wave at the same frequency is also produced. Function derived can modulate a 60 cycle or other frequency carrier to yield a suppressed-carrier waveform useful in servo testing.

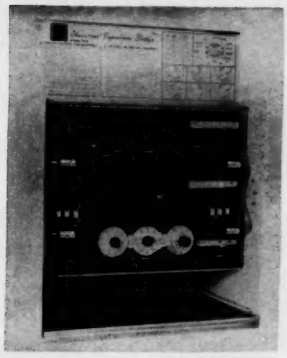
For detailed information, send for data sheets.

tensor
ELECTRIC DEVELOPMENT CO., INC.
1873 Eastern Parkway Brooklyn 33, New York
HY 5-9200

See us Booth 3945 IRE Show

CIRCLE 145 ON READER-SERVICE CARD

IMPEDANCE BRIDGE



New Model 291-A Universal Impedance Measuring System features measurement resolution to 120,005 dial divisions, resistance accuracy of 0.05%, inductance and capacitance accuracies 0.1% at 1 kc. Includes a-c and d-c generators and detectors, providing adequate sensitivity for any specified accuracy throughout measurement range.—*Electro Scientific Industries, Inc., 7524 S. W. Macadam Ave., Portland 19, Ore.*

CIRCLE 314 ON READER-SERVICE CARD

BRIDGE, TRANSFORMER

New Model CRB-4 solid-state Complex Ratio Bridge generates and indicates complex ratio needed to duplicate ratio under test, 50-1000 cps range. Self-contained phase-sensitive null indicator shows when two ratios are equal. Signal input impedance at null greater than 20,000 megohms. New Model RDB-1 DB Rationtran calibrates attenuators, meters, etc. from 0-110 db.—*Gertsch Products, Inc., 3211 S. La Cienga Blvd., Los Angeles 16, Calif.*

CIRCLE 315 ON READER-SERVICE CARD

SIGNAL AMPLIFIER

New 4 cubic in, 4.25-oz Model CA17 Signal Amplifier has −0.5 to +5 v dc output, requires 35 ma at 28 v dc ±5%. Operates with transducers to rated sensitivity of 1.5 to 10 mv/v; uses potentiometers for zero, sensitivity adjustments.—*Statham Instruments, Inc., 12401 W. Olympic Blvd., Los Angeles 64, Calif.*

CIRCLE 316 ON READER-SERVICE CARD

The first

BRIGHTNESS PYROMETER

which is fully

AUTOMATIC *and* CONTINUOUS

PYRO-650*

for temperature measurement, recording and control in the ranges from 1100°F to 7200°F and 600°C to 4000°C.

Brightness pyrometers are widely used for non-contacting, high temperature measurements. However, because existing devices are manually operated, their use has been limited to intermittent temperature measurements of short duration.

Now, PYRO-650 provides the accuracy and repeatability of a Brightness Pyrometer in a fully automatic instrument which is ruggedly designed for continuous temperature measurement, recording and control in plant environments as well as laboratory applications.

IDL also manufactures PYRO-EYE*, a two-color optical pyrometer which offers special advantages for some types of application.

*Trade Mark of Instrument Development Laboratories, Inc.

VISIT BOOTH 1159, PAN PACIFIC AUDITORIUM, LOS ANGELES WESTERN METAL EXPOSITION, MARCH 20-24 or write for brochure.

INSTRUMENT DEVELOPMENT LABORATORIES, INC.

Subsidiary of ROYAL McBEE

67 MECHANIC STREET, ATTLEBORO, MASS., U. S. A.

CIRCLE 146 ON READER-SERVICE CARD

Pressure: to 540 psi.

Ten orifice sizes: 1/64" through 1/4".

Wide voltage range: standard with 115V. AC.; also 12, 24, 208, 230, 460V. AC. 50/60 cycle.

Body: brass bar stock or 18-8 stainless steel. All moving parts, stainless. Seat disc, synthetic rubber. Sizes, 1/8" and 1/4" NPT. Both conduit and grommet types.

Underwriters' listed as a safety valve

Yes, "Master-mite" is the mighty mite of solenoid valves. Useable on a wide range of media including hydrogen, acetylene, etc. Works right in any position. Small, but with extra strength in the Marsh manner. Coils never overheat. Leak tight. Remarkably quiet.

Ask for special bulletin

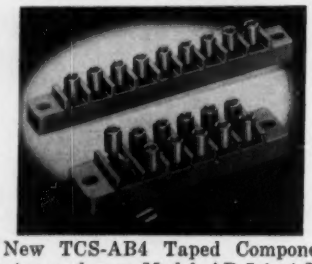
MARSH INSTRUMENT COMPANY
Division of Colorado Oil & Gas Corporation
Dept. 42, Skokie, Ill. Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta. Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas. Eastern Seaboard Warehouse: Marsh Instrument Company, 1209 Anderson Ave., Fort Lee, N. J.

MARSH

GAUGES • THERMOMETERS
VALVES

CIRCLE 147 ON READER-SERVICE CARD

SORTER, BRIDGE



New TCS-AB4 Taped Component Sorter and new Model AB-5-1, 1-MC Limit Bridge with automatic feeding and sorting will be shown at IRE Show.—*Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, N. J.*

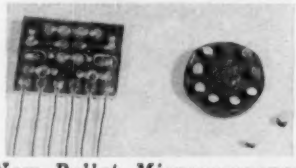
CIRCLE 317 ON READER-SERVICE CARD

TERMINAL BOARDS

Military Terminal Boards; toggle switches with female-clip terminals, as well as standard screw-type and solder type; Kliptite hardware; 600 Series barrier terminal blocks; special devices to meet unusual requirements —all will be on IRE exhibit.—*Kulka Electric Corp., 633-643 S. Fulton Ave., Mt. Vernon, N. Y.*

CIRCLE 318 ON READER-SERVICE CARD

MICRO COMPONENTS



New Pellet Microcomponents (1/10"-dia x 1/16") fit into holes in component boards, and terminals press into slots along board edges, permit Unitized Component Assembly; printed circuit pattern on each board connects with pellets by conductive cement; boards are cast into transparent epoxy blocks (1" x 0.85" x 0.14").—*P. R. Mallory & Co., Inc., 3029 E. Washington St., Indianapolis 6, Ind.*

CIRCLE 319 ON READER-SERVICE CARD

OPERATIONAL AMPLIFIERS

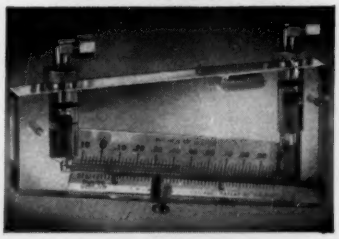
New Model 505A DC Operational Amplifier mounts in 19" rack, operates directly from 115-v 60-cps line, features response to 5 kc and open loop gain of 5000. Chopper-stabilized Model 505AS offers d-c gain in excess of 10^8. Operational block diagram with standard binding posts for input, feedback and output functions are on front panel.—*Micro Gee Products, Inc., Box 1005, Culver City, Calif.*

CIRCLE 320 ON READER-SERVICE CARD

FILTER EFFICIENCY

at a glance...

ANYTIME!



Dwyer

AIR FILTER GAGE

With the Dwyer Air Filter Gage you can be sure of maximum filter efficiency because you know the *exact* time to replace filters, *every time.* Gives a continuous, accurate check that spots inefficient filters, yet prevents waste through premature replacement.

The Dwyer measures filter efficiency the only practical and economical way—via pressure drop. Quickly pays for itself through savings in replacement and service time and greater operating efficiency.

Break-proof plastic construction, lifelong accuracy, simple installation, no moving parts to ever wear out or get out of adjustment. Ranges 0-½", 0-1", 0-2" and 0-3" water. A complete unit with all necessary tubing, fittings, etc.

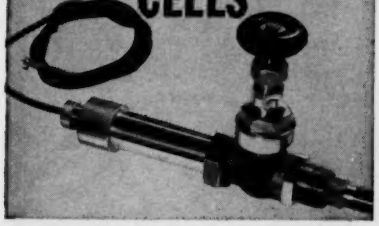
Write for Bulletin C10

F.W. DWYER MFG. CO.

P. O. Box 373-S • MICHIGAN CITY, IND.

CIRCLE 148 ON READER-SERVICE CARD

ONE SOURCE FOR ALL YOUR CONDUCTIVITY CELLS



BODY MATERIAL

Choose from the widest range of body materials...polystyrene, lucite, epoxy, nylon, polyethylene, bakelite, hard-rubber, Teflon, Kel-F, stainless-steel, Monel, nickel and glass to meet every requirement for temperature, pressure and corrosion resistance.

PHYSICAL RANGE

Select the cell specifically designed to meet your application requirements... no need to settle for a universal compromise. Industrial Instruments manufactures conductivity cells for operation under pressures up to 7000 PSI.

CONDUCTIVITY RANGE

The most comprehensive line of cell ranges and constants available anywhere for every application from measurement of ultra-pure water to concentrated solutions of highly corrosive acids, alkalis and salts.

ELECTRODE MATERIALS

Nickel, platinum, graphite, gold or tin ...each one tailored to perform a specific job properly. Submit your particular requirements to us. Over twenty years' experience in the electrolytic conductivity field.

Write on your letterhead for our new Conductivity Catalog.

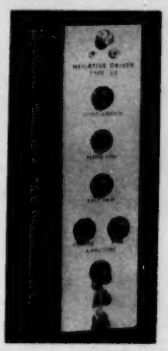
Industrial Instruments

Industrial Instruments Inc.

89 Commerce Road, Cedar Grove, Essex County, N. J.

CIRCLE 149 ON READER-SERVICE CARD

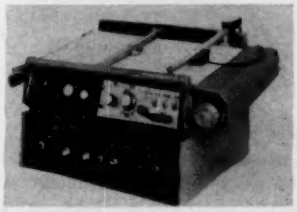
CURRENT DRIVERS



New Solid-state Negative Current Driver Type 52 and Positive Current Driver Type 62 feature current range of 0.1-1.0 amp and ±50 v back voltage, rise and fall times of 0.05-0.5 μsec. Output impedance exceeds 2,000 ohms at 1 amp. Also to be shown: 500-kc quadruple Flip-Flop Circuits, 10-Mc Modules (inverters, flip-flops, pulse amplifiers, etc).—*Digital Equipment Corp., Maynard, Mass.*

CIRCLE 321 ON READER-SERVICE CARD

DELAY SIMULATOR



New Model 2D-5 Transport Delay Simulator combines standard Autograf Model 2D X-Y Recorder and Moseley Type F-2 Optical Line Follower. Provides variable transport delay time, adjustable by changing separation between writing and reading arms or by changing paper speed. Also to be shown: 8-½" x 11" Model 135 and 11" x 16-½" Model 2DR X-Y Recorders, Model 21 True RMS Voltmeter.—*F. L. Moseley Co., 409 N. Fair Oaks Ave., Pasadena, Calif.*

CIRCLE 322 ON READER-SERVICE CARD

DELAY LINES

New Model 192-1, 4 1/2 x 9/16 x 23/32, sealed, magnetostrictive Delay Line offers 20 to 2200 μsec delay with adjustment range of ±4 μsec. Pule repetition rate is 1 Mc max, input pulse width varies from 0.5 to 1.5 μsec.—*Deltime, Inc., 139 Hoyt St., Mamaroneck, N. Y.*

CIRCLE 323 ON READER-SERVICE CARD

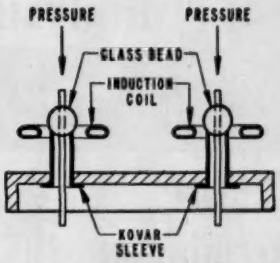
LepeL

HIGH FREQUENCY *Induction* HEATING UNITS

Lepel induction heating equipment is the most practical and efficient source of heat developed for numerous industrial applications

Typical Induction Heating Applications

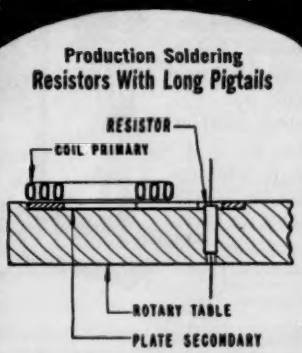
Glass to Metal Seals



Induction heating is ideal for the assembly of glass beads to pre-oxidized Kovar metal sleeves for a header sub-assembly. The glass-Kovar joint area is brought to 1550° F while pressure is applied to the glass beads.

Our engineers will process your work samples and return the completed job with full data and recommendations without cost or obligation.

Production Soldering Resistors With Long Pigtails



Heating occurs in small opening of plate secondary which is electromagnetically coupled to stationary primary. This produces highly localized heating while avoiding intereference of pigtail with the coil. One turntable contains a number of loading positions.

WRITE FOR NEW LEPEL CATALOG

LepeL HIGH FREQUENCY LABORATORIES, INC.

55th ST. & 37th AVE., WOODSIDE 77, N. Y.

CHICAGO OFFICE: 6246 WEST NORTH AVE.

CIRCLE 150 ON READER-SERVICE CARD

DIETERT-DETROIT

CARBON determinator NO 3003

Determine carbon content in just 2 minutes! No complicated mathematics; eliminates costly time-consuming routines. Accurate analysis of borings, mill chips, crushed samples, pellets, etc. Widely used in industrial, commercial and research laboratories.

FREE *Dietert-Detroit 16 page Catalog illustrates both Carbon and Sulphur Determinators and accessory equipment.*

HARRY W. DIETERT CO.
CONTROL EQUIPMENT
9330 ROSELAWN DETROIT 4, MICHIGAN

Send me your Carbon-Sulfur Determinator Catalog.

NAME_____
COMPANY_____
ADDRESS_____
CITY_____ STATE_____

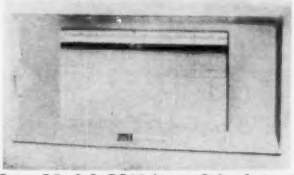
CIRCLE 151 ON READER-SERVICE CARD

LIQUID-LEVEL INDICATOR

New transistorized Sonometer remote indicating gage uses sonar techniques to measure level of most homogenous, relatively suspension-free liquids, ranging from low-temp cryogenics to corrosive acids at elevated temps. Read-out consists of meter indication with scale calibration in feet, inches and gallons. Second read-out provision available in form of 0-100 mv d-c output, directly in proportion to level.—*Acoustica Associates, Inc.*, 10400 *Aviation Blvd., Los Angeles* 45, *Calif.*

CIRCLE 324 ON READER-SERVICE CARD

MULTIPOINT RECORDER



New Model M11A multipoint strip chart Recorder (8½" high, mounts in 19" relay rack) scans and measures 2 to 12 input sources at 5 sec/pt. Plug-in range-change modules permit changes to other temp spans or from temp to mv-spans and vice-versa.—*Westronics, Inc.*, 3605 *McCart, Fort Worth* 10, *Texas.*

CIRCLE 325 ON READER-SERVICE CARD

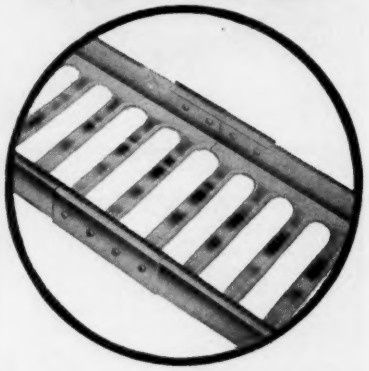
ELECTRONIC COUNTER

New Count/Pak electronic counting system uses photo-electric pick-up for sensing and actuation, accepts input pulse as short as 120 μsec, includes "pulse stretching" circuit to provide accuracy and high speed. Features counting rate of 3000 cpm, instant reset, life cycle over 100 million counts. New "Sentinel" twin photohead device for high-speed lineal measuring counts rotations of delivery roll and senses whether material is present or not.—*Veeder-Root, Electronic Controls Div., Danvers, Mass.*

CIRCLE 326 ON READER-SERVICE CARD

Save Time, Money Speed Installations with . . .

P-W TUBING & CABLE SUPPORT SYSTEMS



P-W's TYPE "E" (PUNCHED BOTTOM) TRAYS—FOR POWER AND CONTROL CABLES AND INSTRUMENT TUBING—ALTHO LESS EXPENSIVE, ARE STRONGER, VERSATILE AND SUPERIOR. TUBING AND CONTROL CABLE CAN BE DROPPED OUT ANYWHERE.

Engineers, Contractors and Installers look for QUALITY, LONG LIFE, AND LABOR SAVINGS in their supports. That's why more and more users are turning to P-W. Among our outstanding improvements are: CONNECTIONS that are quick and easy to install—PRE-CUT SYSTEMS saving installation time—EXTENSION CONNECTORS eliminating field cutting to complete runs—ADJUSTABLE HORIZONTAL and RISER CONNECTORS to go over, under or around pipes, trusses, columns, etc.—BUILT-IN ADJUSTABLE DROP-OUT SECTIONS eliminate cutting out bottom of tray—STRAIGHT SECTIONS available in lengths up to 16' (33 1/3% less connectors and less installation time over 12' lengths).

P-W SUPPORTS are available in hot dip galvanized steel or aluminum, in LADDER, EXPANDED METAL and SOLID TRAYS in addition to Type "E". All systems are interchangeable. Write for Catalog 858-A.

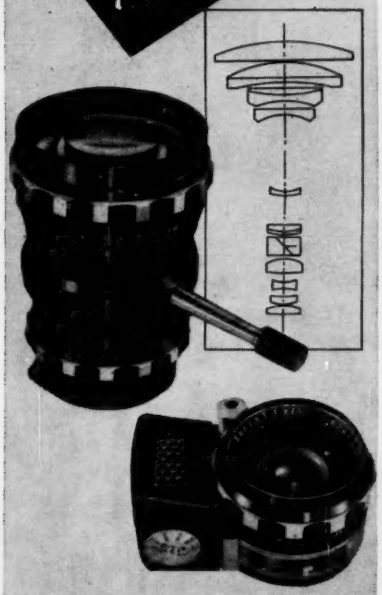
For the utmost in service, contact the appropriate Representative in your territory or P-W direct, regarding inquiries and placing orders.

P-W INDUSTRIES
11200 Roosevelt Blvd.
Philadelphia 15, Pa.

CIRCLE 152 ON READER-SERVICE CARD

ARE YOUR OPTICAL REQUIREMENTS

Very Special?



the lens you need probably is available in the extensive Schneider line of over 300 lens types

Whether for tracking, chemical determination or analysis, or any other usual or unusual lens application, it will pay you to first check your lens requirements with Schneider . . . world's leader in precision optics. Possibly, the exact lens system you require may be standard within Schneider's extensive line . . . or a simple, inexpensive modification may be your answer. In either case, time and costs can be cut appreciably . . . with all the assurance of quality the name Schneider provides. A request on your company letterhead will bring you illustrated catalog and other literature.

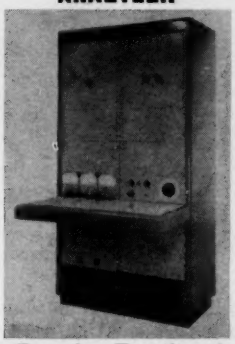
Schneider LENSES

Classics of Optical Precision

BURLEIGH BROOKS, INC.
420 Grand Avenue, Englewood, New Jersey
CHICAGO • HOLLYWOOD • ATLANTA • DALLAS

CIRCLE 153 ON READER-SERVICE CARD

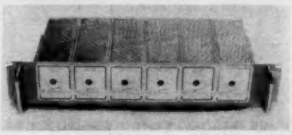
TRANSFER FUNCTION ANALYZER



New Transfer Function Analyzer Model OF-3 determines response characteristics of control, structural, electrical and servo systems. Uses cross-spectral density computation technique, gives output as Nyquist or Bode plots, operates with random or complex periodic driving signals, obtains causal relationship between two signals despite extraneous noise.—*Gulton Industries, Inc.*, 212 *Durham Ave., Metuchen, N. J.*

CIRCLE 327 ON READER-SERVICE CARD

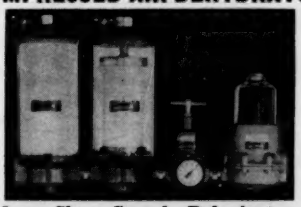
FLOATING POWER SUPPLY



New transistorized Model 10-200 Floating Power Supply for bridge excitation of strain gages and other resistance transducers is used with single-ended output devices in multichannel data acquisition systems. Maintains signal threshold of less than 10 μv; supply adjusts between 8-14 v dc, offers up to 200 ma; regulation better than 0.1%.—*B & F Instruments, Inc.*, 3644 *N. Lawrence St., Phila.* 40, *Pa.*

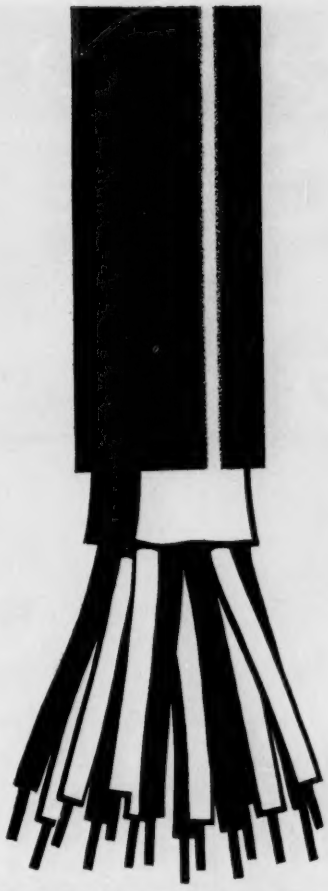
CIRCLE 328 ON READER-SERVICE CARD

COMPRESSED AIR DEHYDRATOR



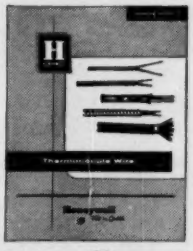
New Chem-Guard Dehydrator is made up of standard units packaged to fit particular application. First unit removes entrained moisture and small dirt particles; second unit controls air pressure; filter removes oil fumes, prohibiting coating of silica-gel desiccant in dryer (third unit) which lowers dew-point of air to −65°F. Separate replacement desiccant charges are rated at maximum of 10 cfm at 100 psi on intermittent or continuous flows of air.—*Wilkerson Corp.*, 1605 *W. Mansfield, Englewood, Col.*

CIRCLE 329 ON READER-SERVICE CARD



MULTIPLE-CONDUCTOR T/C EXTENSION CABLE

Available with from 4 to 48 pairs of solid-conductor temperature-compensated wires. Each wire is numbered, individual conductors are twisted into pairs, each pair is color-coded by wire type. No conduit needed. Supplied in custom and standard constructions. From this one dependable source come thousands of other accessories to help your instruments perform at their very best.



Get details from your Honeywell field engineer, or write today for Catalog G100-2.

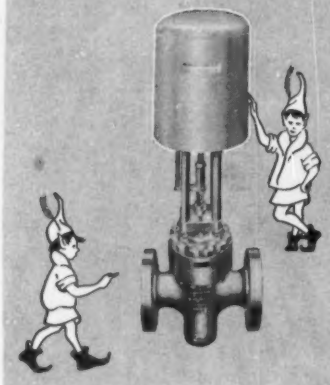
MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

H First in Control SINCE 1885

CIRCLE 154 ON READER-SERVICE CARD

This is a pneumatic hydraulic servoactuator



. . . it is used for high power level positioning in pneumatic control systems. Here in one package is a complete actuator for valves and other loads, combining the high response capabilities of hydraulic operation with the flexibility of pneumatic control. Ask for Technical Bulletin 91441.

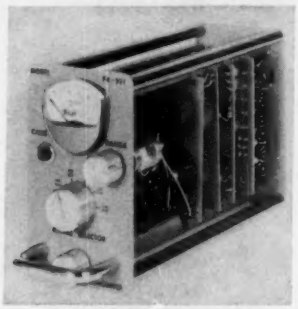
there's a lot of magic in B & F servo components.

Boonshaft and Fuchs Inc.

HATBORO INDUSTRIAL PARK • HATBORO • PA.

CIRCLE 155 ON READER-SERVICE CARD

MODULAR CONVERTER



New FR-500 Series Modular Frequency to DC Converter simultaneously provides 0-5 v dc, amplified pulse, and direct reading. Converts input frequency (from 5-3200 cps in 6 overlapping steps) to dc with 0.1% linearity. Input amplitude varies from 5 mv to 100 v rms without affecting output. Bulletin 112.—*Waugh Engineering Co.*, 7842 *Burnet Ave., Van Nuys, Calif.*

CIRCLE 330 ON READER-SERVICE CARD

100-MC COUNTER

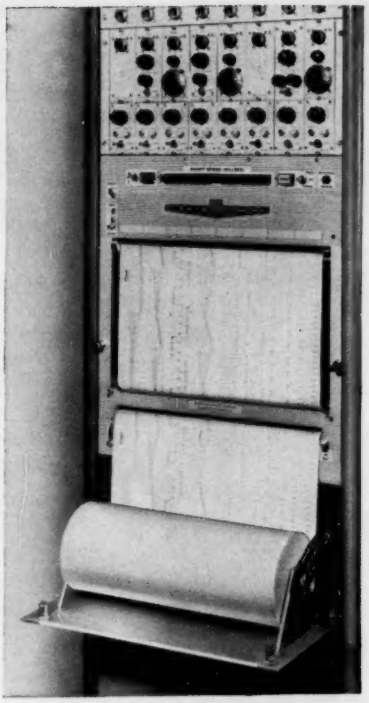
New Model 1040, first 100-Mc direct-counting, solid-state Prescaler, is two-digit instrument compatible with all 1-Mc counting and scaling equipment. New companion instrument, Model 1045 Gated Prescaler, is identical except for fast electronic gate with separate inputs for start and stop. Both feature double-pulse resolution better than 10 nsec.—*Eldorado Electronics*, 2821 *Tenth St., Berkeley, Calif.*

CIRCLE 331 ON READER-SERVICE CARD

VACUUM RECORDER

New Vacuum Recorder (3⅝" x 5⅝") offers 0-1000 micron Hg and 0-20 mm Hg pressure ranges, full voltage regulation. Rugged gage tubes are matched and interchangeable, without readjustment or recalibration; full temperature compensation. Spec. Sheet 322.—*Hastings-Raydist, Inc., Hampton, Va.*

CIRCLE 332 ON READER-SERVICE CARD



AO TRACEMASTER PAPER TAKE-UP STORES ENTIRE 1000 Ft. RECORD!

The AO Tracemaster offers a superior paper take-up mechanism that stores *complete 1000 ft. record* on one roll. Automatic braking device assures constant correct tension (even at full 500 mm/sec. chart speed) to maintain wrinkle-free chart surface for writing notes, interpreting or measuring record.

Convenient, built-in paper cutter permits you to cut the record cleanly and quickly at any point . . . free end can be replaced on take-up spool in just a few seconds.

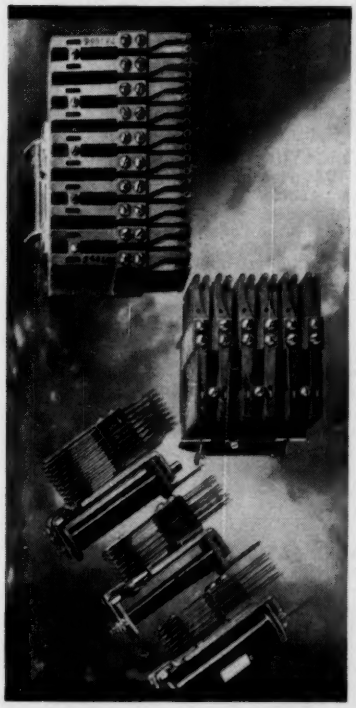
This outstanding convenience and performance of the paper take-up mechanism is typical of every detail of the AO Tracemaster . . . just one more example of the high standards of precision manufacturing that make it the world's finest 8-channel direct writing recorder. Send for complete information . . . *now!*

American Optical Company

Instrument Division • Buffalo 15, New York

CIRCLE 156 ON READER-SERVICE CARD

Relays by Stromberg-Carlson



Telephone-type quality • reliability durability

TYPE A: general-purpose. Up to 20 Form "A" spring combinations.

TYPE B: gang-type. Up to 60 Form "A" spring combinations.

TYPE BB: up to 100 Form "A" springs.

TYPE C: two on one frame. Ideal where space is tight.

TYPE E: characteristics of Type A, plus universal mounting. Interchangeable with other makes.

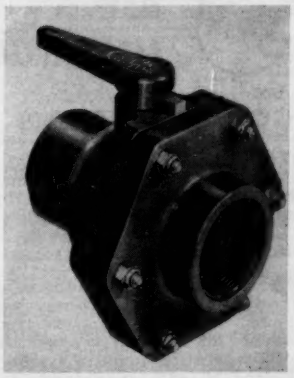
Types A, B, and E are available in high-voltage models. Our assembly know-how is available to guide you in your specific application. If you desire, we can also provide wired mounting assemblies.

Details on request from these Stromberg-Carlson offices: Atlanta—750 Ponce de Leon Place N.E.; Chicago—564 W. Adams Street; Kansas City (Mo.)—2017 Grand Avenue; Rochester—1040 University Avenue; San Francisco—1805 Rollins Road.

STROMBERG-CARLSON
A DIVISION OF
GENERAL DYNAMICS

CIRCLE 157 ON READER-SERVICE CARD

PVC-BALL VALVES



New Polyvinyl chloride ball valves in ½" to 3" sizes assure positive shut-off to 125 psi with ¼ turn of snap-on handle. Straight-through design, no pressure drop. Coupling-like assembly permits each valve half to be fitted to pipe ends, then re-assembled. —*Hoke Inc., 1 Tenakill Park, Cresskill, N. J.*

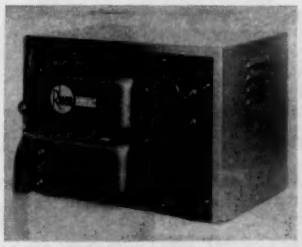
CIRCLE 333 ON READER-SERVICE CARD

HIGH VACUUM VALVES, PLUMBING

New all-metal 1" and 2" Valves and Plumbing Components are bakeable to 450°C, useful at 10^{-10} mm Hg and lower. Conductance is variable from 60 liter/sec to less than 10^{-13} liter/sec with 2" valve and from 10 liter/sec to less than 10^{-14} liter/sec with 1" valve. —*Granville-Phillips Co., Box 198, Pullman, Wash.*

CIRCLE 334 ON READER-SERVICE CARD

PHOTOCELL READER



New transistorized Photocell Reader sensing element is one piece of silicon containing eight information-track and one timing-track channels. Unit handles 5, 7, & 8 channel tapes, paper or aluminum Mylar types, at 100 characters/sec. Stops on character.—*Rheem Manufacturing Co., 400 Park Ave., New York 22, N. Y.*

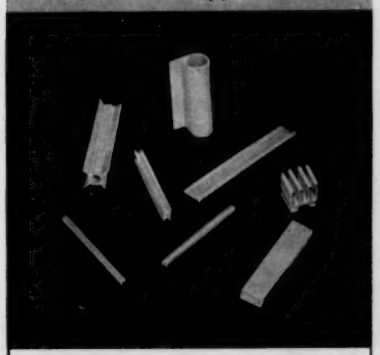
CIRCLE 335 ON READER-SERVICE CARD

NO MOLDS—NO WASTE
NO MACHINING

PF EXTRUDED TEFLON* SHAPES

Reduce Cost of Components

for electrical applications



Some of the many shapes extruded by Pennsylvania Fluorocarbon for the electrical and electronic industries include: shaped insulators, spacers, supporting channels and terminals.

These shapes offer:

- a dielectric strength from 500 to 2000 volts/mil.
- stability—no change of electrical properties with temperature (-25° C. to +250°C.) or frequency (60 cycles to 100 mc)
- zero moisture absorption
- a continuous service temperature range of 250°C.—intermittent to 300°C.

Extreme Dimensional Accuracy Assured On Any Appropriate Design

PF extruded shapes made from Teflon allow design engineers to incorporate the dielectric strength of Teflon into their products for electrical and electronic applications, economically. PF extrudes intricate Teflon shapes to extremely close tolerances, cuts them to lengths, post forms to requirements and performs any auxiliary machining steps. Molds are eliminated, there is no waste of Teflon and, frequently, no additional finishing operations are necessary. Result? Teflon components of extreme accuracy at lower cost.

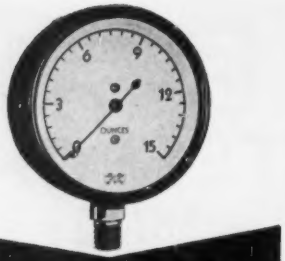
Write, wire or call for a quotation on your particular Teflon component requirements, regardless of the intricacy of the shape. Shapes ranging from 2500 feet per pound to 6 feet per pound can be extruded.

PENNSYLVANIA FLUOROCARBON CO., INC.

1115 N. 38th Street, Phila. 4, Pa.
EVergreen 6-0603 TWX: PH 252

*Du Pont registered trademark

CIRCLE 158 ON READER-SERVICE CARD



MARSHALLTOWN

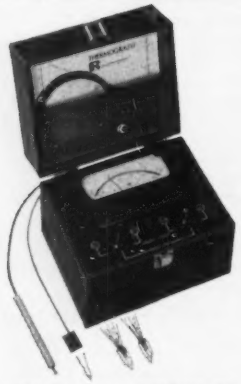
DIAPHRAGM GAUGES

for accurate pressure measurement in ounces or inches of water

Standard dials reading in inches of water, ounces, centimeters or millimeters up to 10 P.S.I. All Marshalltown diaphragm gauges are extremely sensitive and accurately measures very low pressures.

Let Marshalltown answer your gauge problems . . . write for information and prices.

MARSHALLTOWN MANUFACTURING, INC.
A Subsidiary of The Electric Autolite Company
MARSHALLTOWN, IOWA
CIRCLE 159 ON READER-SERVICE CARD



FOR FAST, SIMPLIFIED TEMPERATURE MEASUREMENTS

The RESCON THERMAL TEST SET

A compact, portable unit for obtaining temperature measurements in electronic equipment — from the individual component to the package itself. Applications include: transistors, diodes, tubes, transformers, micro-miniature circuits, etc.

Direct readings . . . no calibrations . . . rugged construction.

RESCON ELECTRONICS CORPORATIONS
151 Bear Hill Road, Waltham 54, Mass.
TWinbrook 9-8600

Designers and Manufacturers of Electronic Test Equipment

CIRCLE 160 ON READER-SERVICE CARD

ICS NEW LITERATURE

CONTROL SYSTEMS

SMOKEHOUSE CONTROL SYSTEM. 2-page bulletin describes automatic smokehouse control system and includes sample chart record.—Calgon Co., Hagan Center, Pittsburgh 30, Pa.
CIRCLE 336 ON READER-SERVICE CARD

TELEMETERING. 8-page bulletin describes Chronoflow Telemetering equipment and systems, gives basics of transmitter and receiver operation in a time-duration impulse system.—B-I-F Industries, 345 Harris Ave., Providence, R. I.
CIRCLE 337 ON READER-SERVICE CARD

BOILER AUTOMATION. 8-page Bulletin G-101 presents pros and cons of automated boiler operation.—Babcock & Wilcox Co., 161 E. 42 St., New York, N. Y.
CIRCLE 338 ON READER-SERVICE CARD

VALVES

PRESSURE REGULATORS. 2-page Bulletin 132 details Reliance Type CBVA 400 and 600 pressure regulators for reducing and boiler fuel applications.—American Meter Co., 920 Payne Ave., Erie 6, Pa.
CIRCLE 339 ON READER-SERVICE CARD

TEMP REGULATORS. 32-page Catalog 360 describes heaters, transformers, regulators, pumps, stirrers, relays.—American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md.
CIRCLE 340 ON READER-SERVICE CARD

VALVES. 2-page sheet describes bellows-sealed, air-operated solenoid controlled valves (Type PV) for use in vacuum applications.—Vacuum-Electronics Corp., Terminal Dr., Plainview, L. I., N. Y.
CIRCLE 341 ON READER-SERVICE CARD

FLOW, PUMPS

Metering Pumps. 8-page Catalog 420.-100 features Series 100 Pump for metering against pressures up to 1200 psi within ±1%.—Wallace & Tiernan Inc., 25 Main St., Belleville 9, N. J.
CIRCLE 342 ON READER-SERVICE CARD

SIGHT-FLOW INDICATORS which feature rotatable flanges are described in 2-page Design-Spec Sheet DS-820.—Brooks Instrument Co., Inc., Hatfield, Pa.
CIRCLE 343 ON READER-SERVICE CARD

FLOW, LEVEL, POSITION. 4-page bulletin describes and gives applications of electro-magnetic flow switches, level switches, and position indicator.—Gems Co., Inc., Sheppard Lane, Farmington, Conn.
CIRCLE 344 ON READER-SERVICE CARD

FLOWMETERS. 4-page Bulletin 10A-1010 describes four variable-area, wide-range flowmeter kits; 2-page Bulletin 10A2147 describes armored, glass tube, variable-area indicating flowmeter for high pressure and temperature service.—Fischer & Porter Co., 800 Jacksonville Rd., Warminster, Pa.
CIRCLE 345 ON READER-SERVICE CARD

FORCE, PRESSURE, VACUUM

PRESSURE TRANSDUCERS. 5 data sheets include glossary of terms and description of SP-2 series pressure transducers, which cover 0-300 through 0-5000 psi.—Standard Controls, 1130 Poplar Place, Seattle 44, Wash.
CIRCLE 346 ON READER-SERVICE CARD

VACUUM PUMPS. 16-page catalog describes mechanical high vacuum pumps, gages, systems, & components.—Central Scientific Co., Subs. Cenco Instruments Corp., 1700 W. Irving Pk. Rd., Chicago 13, Ill.
CIRCLE 347 ON READER-SERVICE CARD

VIBRATION/STRAIN. 4-page Bulletin K19A describes vibration transducers and exciters, strain gages, load cells and beams, engine monitoring equipment and associated read-out devices and recorders.—Korfund Co., Inc., Instruments and Acoustics Div., 86A Cantiague Rd., Westbury, L. I., N. Y.
CIRCLE 348 ON READER-SERVICE CARD

TIME, SPEED, COUNT

DIAL TIMER. 4-page Bulletin N-309 describes Series 309 Push-Button Automatic Reset Dial Timer, application, construction, functions, etc.—Automatic Timing & Controls, Inc., King of Prussia, Pa.
CIRCLE 349 ON READER-SERVICE CARD

AUTOMATIC PROGRAMMING. 8-page Bulletin AR-1060 describes characteristics of automatic programming systems for commercial and scientific Bendix G-15 computer applications, includes partially coded illustrations of typical problems.—Bendix Computer Div., 5630 Arbor Vitae, Los Angeles 45, Calif.
CIRCLE 350 ON READER-SERVICE CARD

TIMING UNITS. 8-page Bulletin G-1328 describes timing motors and time and torque controls.—Haydon Div., General Time Corp., Torrington, Conn.
CIRCLE 351 ON READER-SERVICE CARD

TACHOMETERS. 4-page bulletin covers line of electric tachometers.—Electro-Mechano Co., 241 E. Erie St., Milwaukee, Wis.
CIRCLE 352 ON READER-SERVICE CARD

TACHOMETERS with chronometric feature and 1/10 of 1% accuracy are described in 2-page foldout.—Technical Oil Tool Corp., 1057 N. La Brea Ave., Los Angeles 38, Calif.
CIRCLE 353 ON READER-SERVICE CARD

MECHANICAL COUNTER. 2-page catalog sheet details Series CM-3000 bidirectional mechanical counter with 7/16″ high numerals.—Chicago Dynamic Industries, Inc., Precision Products Div., 1725 Diversey Blvd., Chicago 14, Ill.
CIRCLE 354 ON READER-SERVICE CARD

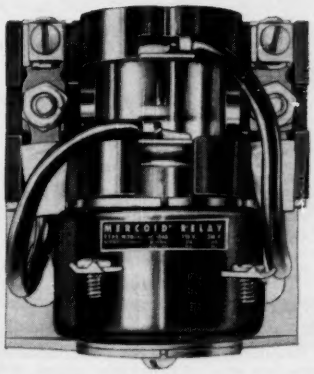
DC RECEIVERS. 2-page Spec Sheet E-12-4 describes classes of d-c receivers for converting transducer signals to pneumatic or electric signals to drive recorder pen.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.
CIRCLE 355 ON READER-SERVICE CARD

35 AMP

* 120V. Non-Inductive A.C. heater loads

Plunger Type

MERCURY RELAY



by

MERCOID

If you need reliability and durability, this quality built relay by Mercoid is your answer.

For heavy duty loads, such as resistance heating, (domestic, commercial, industrial)—heat treating furnaces, drying equipment, welding, lighting, illuminated signs, score boards.

Hermetically sealed mercury to mercury contact provides visible on-off operation. Silent and chatterless. Quickly mounted, easily wired. Speeds up to 100 operations per minute.

Available normally open;

CONTACT RATING:

LOAD			*NON INDUCTIVE HEATER LOADS	
	AC	DC	AC ONLY	
120V.	30A.	15A.	120V.	35A.
240V.	20A.	10A.	240V.	25A.
440V.	8A.	—	440V.	10A.

WRITE FOR BULLETIN 0-20

THE MERCOID CORPORATION
4211 Belmont Ave., Chicago 41, Ill.

CIRCLE 161 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC INSTRUMENTS

MEASURING INSTRUMENTS. 6-page brochure summarizes instruments for precision measurement of voltage, d-c resistance, and thermal radiation. —Eppley Laboratory, Inc., Sheffield Ave., Newport, R. I.

CIRCLE 356 ON READER-SERVICE CARD

VIBRATION EXCITER. 28-page booklet describes electrical and mechanical performance characteristics of high frequency Calibration Exciter Model 4290.—B & K Instruments, Inc., 3044 W. 106 St., Cleveland 11, Ohio.

CIRCLE 357 ON READER-SERVICE CARD

OSCILLOSCOPES. 6-page brochure describes Model 112-9 Dual Channel Sampling Oscilloscope with risetime of 0.4 nanoseconds.—Lumatron Electronics, Inc., 116 County Courthouse Rd., New Hyde Park, L. I., N. Y.

CIRCLE 358 ON READER-SERVICE CARD

RESISTANCE BRIDGES. 2-page sheet details Synchro Bridge KT 427775-2A and Resolver Bridge KT 427771-2A, which measure accuracy of synchros or resolvers by proportional voltage method.—Kearfott Div., General Precision, Inc., Little Falls, N. J.

CIRCLE 359 ON READER-SERVICE CARD

CONVERTERS. 2-page Bulletin 112 describes operation, provides specs for FR-500 Series of Modular Frequency to D-C Converters; 7-page Report 60-20C details operation and circuitry.—Waugh Engineering Co., 7842 Burnet Ave., Van Nuys, Calif.

CIRCLE 360 ON READER-SERVICE CARD

OSCILLOSCOPES. 15-page abridged catalog describes oscilloscopes and associated electronic equipment.—Tektronix, Inc., Box 500, Beaverton, Ore.

CIRCLE 361 ON READER-SERVICE CARD

RECORDER. 4-page Bulletin R-301 describes transistorized miniature Potentiometer/Receiver Recorder which uses 1, 2 or 3 pens on 4" wide chart. —DeVar Systems, Inc., 494 Glenbrook Rd., Glenbrook, Conn.

CIRCLE 362 ON READER-SERVICE CARD

RECORDING VOLTMETER. 2-page sheet describes Model 1122B-60 Expanded Scale Recording Voltmeter.—Brenner-Fiedler & Associates, Inc., 7563 Melrose Ave., Los Angeles 46, Calif.

CIRCLE 363 ON READER-SERVICE CARD

DATA HANDLING

TRANSMITTERS, REPEATERS. 2-page Bulletin S-608 describes Series TL low pressure and Series TH high pressure synchro transmitters; 2-page Bulletin S-609 describes matching low and high pressure repeaters.—Servonic Instruments, Inc., 1644 Whittier Ave., Costa Mesa, Calif.

CIRCLE 364 ON READER-SERVICE CARD

PORTABLE COMPUTER. 6-page brochure describes 28-lb Model 3500 Analog Computer for desk top and bench operation.—Donner Scientific Co., Subs. Systron-Donner Corp., Concord, Calif.

CIRCLE 365 ON READER-SERVICE CARD

MAGNETIC TAPE. 7-page Bulletin 3400 describes 460 Series Recorder/Reproducer, which can be changed from reel to loop operation without rehandling tape or changing transport.—Sangamo Electric Co., Springfield, Ill.

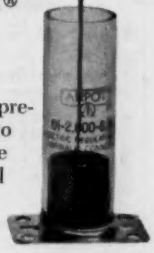
CIRCLE 366 ON READER-SERVICE CARD

When the

UNPREDICTABLE

happens

• • • the kind that creeps into the performance of newly completed systems. (Excess vibration here — slight time delay or damping needed there. Or perhaps stability doesn't match the data projected on paper.) To counter these variations, many of our customers have found the AIRPOT® an inexpensive problem solver.



AIRPOT is an air-damping dashpot; precisely constructed to operate within close tolerances. Its small size will rarely disturb a system's basic design.

To learn more about the AIRPOT, contact us at:

ELECTRIC REGULATOR CORPORATION
NORWALK, CONNECTICUT
"leaders in automatic control and regulation"

CIRCLE 162 ON READER-SERVICE CARD

SPOT CRITICAL TEMPERATURES ACCURATELY with

NEW PYRO MICRO-OPTICAL PYROMETER

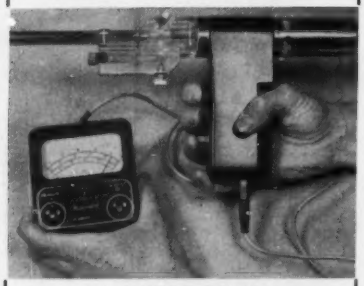
All-purpose PYRO Micro-Optical precisely measures targets as small as .001" in diameter or objects at remote distances to 2°C reproducibility! Temperature scales 700° - 3200°C (1300° - 5800°F).

Send for FREE catalog No. 95.

PYROMETER INSTRUMENT CO. INC
BERGENFIELD 4, NEW JERSEY

CIRCLE 163 ON READER-SERVICE CARD

Humidity measurements within ± 0.5% RH!



A+ HYGROPHIL
thermistor psychrometer

- Measures temperatures from 10°F to 176°F
- Response time: 10 to 20 seconds for final reading
- Reproducible readings every time. Readability ¼°
- Indicates wet and dry bulb thermistor (resistance temperature detector) readings of air temperatures.

$290 complete with case
Specify F° or C° scale
Write for Bulletin

Atkins Technical Inc.
1276 W. Third Street
Cleveland 13, Ohio
Phone: SU 1-1332
temperature and humidity instrumentation

CIRCLE 164 ON READER-SERVICE CARD

HARDNESS TESTING

The Shore Scleroscope for testing the hardness of metals and other materials. Accurate, rapid, completely portable, non-marring. Over 40,000 in use. Pioneer American standard since 1907.
The Shore Durometer for testing the hardness of rubber and rubber-like materials. May be used free hand or mounted on Operating Stand. Conform to ASTM D676, D1484, & D1706.

INSTRUMENT & MFG. CO., INC.
90-35 VAN WYCK EXPRESSWAY
JAMAICA 35, N.Y., U.S.A.

CIRCLE 165 ON READER-SERVICE CARD

TAPE SPOOLER. 2-page Data Sheet TS-400 describes Model TS-400 Automatic Tape Spooler for use with unidirectional and bidirectional tape readers.—Electronic Engineering Co. of Calif., 1601 E. Chestnut Ave., Santa Ana, Calif.

CIRCLE 367 ON READER-SERVICE CARD

MEMORY SYSTEM. 4-page reprint describes ferrite magnetic-core "associative memory" with built-in "shortcuts" to stored information.—International Business Machines Corp., 590 Madison Ave., New York 22, N. Y.

CIRCLE 368 ON READER-SERVICE CARD

MEMORY MATRIX. 4-page Bulletin 25 and two 2-page data sheets detail microstack miniaturized memory plane for use with coincident current memory systems.—Applied Logics Dept., General Ceramics, Keasbey, N. J.

CIRCLE 369 ON READER-SERVICE CARD

CARD READER. 2-page Data Sheet DPS-A43 details CR-201 Card Reader to transport cards from hopper, past two read stations, into card stacker at 30 cards/min.—Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 370 ON READER-SERVICE CARD

ANALYTICAL

CHROMATOGRAPHY. 2-page Bulletin 26212 describes advanced chromatographic closed loop process control capabilities.—Consolidated Electrodynamics Corp., Subs. Bell & Howell, 360 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 371 ON READER-SERVICE CARD

CHROMATOGRAPH. 15-page Bulletin 787 describes operating principle and applications of GC-2A Gas Chromatograph and accessories.—Beckman Scientific and Process Instruments Div., 2500 Fullerton Road, Fullerton, Calif.

CIRCLE 372 ON READER-SERVICE CARD

VAPOR FRACTOMETER. Eight 2-page data sheets describe components available for Model 184-B Process Vapor Fractometer sensing units, programmer chassis, pneumatic control, building block sampling systems, etc.—Instrument Div., Perkin-Elmer Corp., Norwalk, Conn.

CIRCLE 373 ON READER-SERVICE CARD

GAS DETECTOR. 4-page bulletin describes Model 60 portable Gas Detector.—Brothers Chemical Co., 575 Forest St., Orange, N. J.

CIRCLE 374 ON READER-SERVICE CARD

COLORIMETRY. 4-page brochure describes Green-Bartlett Colorimeter for high speed, automatic color control; 10-page booklet presents over-view of plant, facilities, research and engineering experience.—Colorimetry Div., Allied Research Associates, Inc., 43 Leon St., Boston 15, Mass.

CIRCLE 375 ON READER-SERVICE CARD

X-RAY ANALYSIS. 4-page folder discusses analytical procedure for uranium fuel alloy ingots, stainless steels, silver-gold previous alloys; etc.; 4-page folder details Gulf's 100-kv X-ray Spectrograph for analyzing lubricating oils, crudes, distillates, etc.—Philips Electronic Instruments, 750 S. Fulton Ave., Mount Vernon, N. Y.

CIRCLE 376 ON READER-SERVICE CARD

HELPFUL DATA ON
Nuclear Instrumentation

Get the latest data on instruments for detecting, measuring and recording radioactivity. Ask for this NMC literature.

FREE CATALOGS!

Monitoring Catalog M-60 shows individual units and complete systems for monitoring airborne particulate, water, stack gas, etc.

Instruments Catalog PC-60 shows the famous NMC proportional counter (PC3A) and associated instruments.

Other catalogs show NMC portable survey instruments, scalers, well counters, and medical isotope instruments.

FREE BULLETINS!

Feature new instruments and new techniques for research, testing, processing, production, inspection and personnel safety. Mailed on request.

PHONE COLLECT NMC LIBERTY 6-2415

Nuclear Measurements Corp.
2460 W. ARLINGTON • INDIANAPOLIS 18, IND.

International Office: 13 E. 40th St., New York 16, N.Y.

CIRCLE 166 ON READER-SERVICE CARD

ALL DIGITS CAN BE READ FROM ANY ANGLE

IN-LINE DIGITAL READOUT

featuring

ONE-PLANE PRESENTATION

Series 10000

Over 1000 firms throughout the world in just a few years prove unprecedented acceptance of IEE digital readouts.

PRICE COMPLETE $18.00

QUANTITY PRICES ON REQUEST

Binary-To-Decimal Decoders Available.

WRITE TODAY FOR COMPLETE SPECIFICATIONS

Representatives in principal cities

INDUSTRIAL ELECTRONIC ENGINEERS, INC.
5528 Vineland Avenue
North Hollywood, California

CIRCLE 167 ON READER-SERVICE CARD

MICO

Heavy-Duty 2 & 3 Dimensional Engraver

FOR:
Engraving Nameplates
Fine Routing Work
Profiling Small Objects
Making Small Dies and Molds

FEATURES OF NEW ENGRAVER

1. Six Reduction Ratios—From 1.5:1 to 4:1.
2. Heavier bearings in micrometer spindle.
3. New 1/10 H.P. Ball Bearing Motor permits continuous operation for die or mold work in steel.
4. Absolute accuracy for three-dimensional reproduction.
5. Uses standard taper-shank cutters or ⅛" diameter straight shank cutters and end mills.
6. Copy and work right-side-up: always in direct view of operator.
7. Many attachments available to increase versatility of machine.

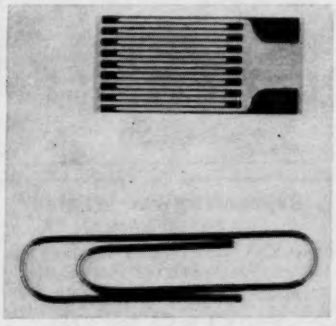
Send for Illustrated Catalogs

MICO INSTRUMENT CO.

86N Trowbridge St., Cambridge 38, Mass.

CIRCLE 168 ON READER-SERVICE CARD

New
Foil Strain Gages



Unique process precision punched. Stable and high uniform quality. Material: Advance on thin multilayer laminated epoxy and fiber backing. Size: ½" Resistance: 120 Ohms. Total Thickness: .002". Independent research laboratory tests show:—

Negligible hysteresis. Creep or drift and other variables on long time test total less than 1%. No prior cycling needed. Transverse strain sensitivity negligible.

Other smaller sizes will be available very shortly. No limitation as to type of material by this process for high or low temperature. Special order inquiries invited. **Additional information on request.**

Dentronics, Inc.

16 Bland Ave. • Emerson, N. J.

CIRCLE 169 ON READER-SERVICE CARD

TESTING, GAGING

TEST INSTRUMENTS. 12-page Catalog 10-1.3 describes instruments for measuring high voltage breakdown, dielectric strength, insulation resistance, power supplies, etc.—Associated Research, Inc., 3777 W. Belmont Ave., Chicago 18, Ill.
CIRCLE 377 ON READER-SERVICE CARD

GAGING. Series of data sheets detail optical gaging equipment, rotary card press gages, lead starightening and taping machines, etc.—Universal Instruments Corp., Box 825, Binghamton, N. Y.
CIRCLE 378 ON READER-SERVICE CARD

MISCELLANEOUS

CONTROL LINKAGE. 12-page Bulletin P81-5 describes linkage arrangements for fan damper, stoker speed, coal feeder gate and feed pump fluid coupling control.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.
CIRCLE 379 ON READER-SERVICE CARD

MONITORING SYSTEM. 8-page booklet describes high-speed, continuous B1020 Electronic System which monitors any condition represented by electrical contact closure.—Lynch Communication Systems Inc., 695 Bryant St., San Francisco 7, Calif.
CIRCLE 380 ON READER-SERVICE CARD

RADIATION DETECTION. 4-page bulletin describes monitoring and alarm systems.—Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.
CIRCLE 381 ON READER-SERVICE CARD

ENVIRONMENTAL CHAMBERS—refrigerated, altitude, humidity, salt spray, etc.—are introduced in 2-page brochure.—Bemco Inc., 11631 Vanowen St., North Hollywood, Calif.
CIRCLE 382 ON READER-SERVICE CARD

DENSITY MEASUREMENT. 2-page Data Sheet P-8072 defines terms, describes Model 930 Air Comparison Pycnometer, which measures volume, density, and porosity on powdery, granular, porous, and irregularly shaped solids.—Beckman Scientific and Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.
CIRCLE 383 ON READER-SERVICE CARD

TIME SCOPE LABELS. 4-page Bulletin 60L describes labels, available in a dispenser box, designed for routine and pathological slide labeling procedures.—Professional Tape Co., Inc., 355 Burlington Rd., Riverside, Ill.
CIRCLE 384 ON READER-SERVICE CARD

STERILE INDICATOR TAPE. 4-page bulletin describes uses of labeling tape known as "TSI TAPE" (Time Sterile Indicator Tape).—Professional Tape Co., Inc., 355 Burlington Ave., Riverside, Ill.
CIRCLE 385 ON READER-SERVICE CARD

PHYSIOLOGICAL-GAS ANALYZER. 4-page Form S-160 describes the Beckman/Spinco Model 160 Physiological-Gas Analyzer for in-vivo measurements of pO_2 in blood, cerebrospinal fluid, brain tissue, and other body fluids and tissues.—Beckman Instruments Inc., Spinco Div., 1117 California Ave., Palo Alto, Calif.
CIRCLE 386 ON READER-SERVICE CARD

EXAMINING TABLES. 8-page Brochure gives factual information on the Mark II and Mark III series examining tables.—Shampaine Industries, 1920 South Jefferson Ave., St. Louis 4, Mo.
CIRCLE 387 ON READER-SERVICE CARD

MODEL **4005** *with* AMBITROL V-I

CONSTANT VOLTAGE
CONSTANT CURRENT
with
PROGRAMMABLE CROSSOVER

$143.50
F.O.B. FACTORY

Other Models Available Write For Catalog

Model 4005 is a 1-40 volt, 500 ma, regulated DC power supply incorporating AMBITROL.* The AMBITROL* circuit will switch *automatically* to either voltage regulation or current regulation at any point predetermined by the operator, with continuous control of voltage or current to .05%.

*TM

Power Designs inc.

1700 SHAMES DRIVE
WESTBURY, NEW YORK
EDgewood 3-6200 (LD Area Code 516)
IRE SHOW—BOOTH 1516

CIRCLE 170 ON READER-SERVICE CARD

A versatile recording/reproducing system capable of simultaneous audio recording on any number of channels; transistorized plug-in circuitry . . . low maintenance . . . non-technician-operated. Applicable as a language laboratory recorder/reproducer, airport communications monitoring system, law enforcement communications recorder, and others.

MULTI-CHANNEL INSTRUMENTATION SYSTEMS

We also invite your inquiry on our 24-hour continuous-loop recorder/reproducer.

MAGNASYNC CORPORATION

5544 Satsuma Avenue
North Hollywood, Calif.
Phone: TRiangle 7-0965

International leaders in the design and manufacture of magnetic recording systems.

CIRCLE 171 ON READER-SERVICE CARD

IGS SEARCHLITE SECTION

INDUSTRIAL TACHOMETERS

PORTABLE and STATIONARY
To indicate
RPM, FPM, YPM, etc.
Bulletin No. 1048

HERMAN H. STICHT CO., INC.
27 PARK PLACE, NEW YORK 7, N. Y.

CIRCLE 172 ON READER-SERVICE CARD

ALL-STATE'S PLASTIC MFG. CO.
8311 WEST SCHUBERT AVE. • CHICAGO 47, ILLINOIS

UTILITY - BLACK
Loop Type
SUPPORTS
made of **NYLON**
WIRE TIES

CIRCLE 173 ON READER-SERVICE CARD

BEAM COMPASS

SAVE TIME and MONEY

Beam lengths from 7" to 78½" one piece anodized aluminum. Coursers available in Aluminum, Nylon, or attractive Plastic. Sets available, individually priced from $3.45 or made up to individual requirements. (15% quantity discount on 3 or more sets)
NON-SLIP "GRIP-RINGS" furnished with all points.
Send for Circular and Price List Today

FERANCE Construction Co.
28 Woodside Drive • Penfield, N. Y.

CIRCLE 174 ON READER-SERVICE CARD

Fixed Set Thermostats

ANY SIZE, ANGLE OR USE
SETTING RANGE: —35°C to 370°C
SET SENSITIVITY: ±.01°C

Guaranteed sensitivity . . . year-in, year-out reliability . . . accurate control of temperature in ovens, electronic equipment, baths, ducts, freezers, fire alarms, incubators, analytic instruments, etc. Triple distilled mercury; filled at still. Hermetically sealed with dry hydrogen at 75 psi. Calibrated to Bur. Standards accuracy. Priced 10% to 15% lower than competitive lines.

FREE CATALOGUE WRITE
PHILADELPHIA SCIENTIFIC GLASS COMPANY
21 PALETOWN RD., QUAKERTOWN, PA.

CIRCLE 175 ON READER-SERVICE CARD

PYROTEL
AUTOMATES • SAFEGUARDS
HEATING PROCESSES

Non contacting radiation pyrometer. For *inaccessible, moving, or fragile targets. Perfect for induction or resistance heating, or* with furnace, crucible or flame. Fast acting and accurate.

PYROTEL *gives meter indication, recording* output and relay control. It will monitor, signal or control extrusion, hot forming, web drying, forging, heat treating, melting or hardening processes. Fast, non-corroding and dependable operation proved by leading manufacturers.

Models are available for all temperature ranges, from 140° F. upwards. Versatile, accurate and dependable. Write for information, recommendation and quotation.
Photoelectric controls also available.

MASON INSTRUMENT COMPANY
P.O. Box 683, Mamaroneck, N. Y.
Telephone OWens 8-6222
Repr. inquiries invited.

CIRCLE 176 ON READER-SERVICE CARD

Model HT-12 Four-Range Tachometer
Centrifugal tachometer that measures revolutions per minute and surface speeds.

TOTAL RANGE: 90-12,000 RPM
1st — 90-360 RPM
2nd — 300-1200 RPM
3rd — 900-3600 RPM
4th — 3000-12000 RPM
Feet per minute—one half the dial reading with use of 6" disc wheel.

Advantages: Accuracy—±0.5% • Stop button feature • Instantaneous readings • 3" easy to read dial • Light—approx. 14 oz.

Kernco Instruments Co., Inc.
Box 1284, Church St. Station
New York 8, N. Y.

CIRCLE 177 ON READER-SERVICE CARD

SMITHS TACHOMETERS
For Precise and Rapid Measurements of
SHAFT SPEEDS CUTTING SPEEDS SURFACE SPEEDS

- **Magnetic Design** Steady readings accurate to ±0.5%
- **Self-Powered** Needs no battery.
- **Hold Button**
- **Overspeed Protection** Inherent
- **Instantaneous Reading** No timing
- **Nine Ranges**

Complete Service Facilities — Send for Details and Literature

CLARENCE J. MARX CO.
Box 4033, Cleveland 23, Ohio

CIRCLE 178 ON READER-SERVICE CARD

REBUILT INSTRUMENTS

Many Temperature Controllers, Precision Indicators, Continuous Line & Multiple Point Recorders; Leeds & Northrup Speedomax, Micromax; M.H. Brown Electroniks; and other makes. Also Strain Gauge Recorders & Potter Flow Recorders & Indicators.

INSTRULAB, INC.
1205 Lamar St. • Dayton 4, Ohio
BA3-2241

CIRCLE 179 ON READER-SERVICE CARD

---

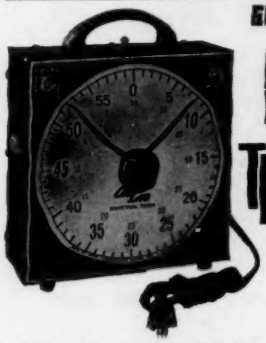
the MACK phaertltron
. . . the only Mercury Relay* with a Teflon plunger bearing surface

Your assurance of silent and extremely reliable performance.
Write or call for details, test samples.
*Has U.S. Pat. Off. Other Pats. Pend.

Mack Electric Devices INC.
Box 97, Wyncote, Pa. Phone TUrner 4-8123
Teflon-DuPont Trade Name for Tetrafluoroethylene Resin

CIRCLE 180 ON READER-SERVICE CARD

ELECTRIC LAB TIMER



Giant 8" Dial

GRA LAB INTERVAL TIMER Automatic signalling and switching over unusually wide range of 3600 possible setting.

GRA LAB MICRO TIMER 1/10 sec. or 1/1000 min. stop clock. Remote start stop control. Write for catalog.

DIMCO-GRAY COMPANY
212 E. SIXTH ST., DAYTON 2, OHIO

CIRCLE 181 ON READER-SERVICE CARD

REPRESENTATIVES WANTED

Well established company with expanding industrial lines—

basically drying, cooling and purification of air and gas flows. Territories open all states except: N.Y., Pa., N.J., Calif., Ohio, Ill., Mich., Ala. Reply with details, products handled, manufacturers represented and territory covered to

Box #383

Representatives Wanted
AREAS OPEN
Wash.-Ore., New England, Colorado-New Mexico, Ala.-Tenn., and Fla.-Ga.
Industrial and laboratory instruments
WRITE I & CS Box #384.

SIZES AND RATES FOR SEARCHLITE SECTION

2⅛" x 1"	25.50
2⅛" x 1⅛"	28.34
2⅛" x 1½"	36.84
2⅛" x 2"	48.17
2⅛" x 2⅜"	56.67

IGS INDUSTRY NEWS

RAY V. LONG

MATTHEW GOULD

DYNEL, INC., is a new firm located in the Los Angeles area at 1401 South Alameda St., Compton, headed by *Ray V. Long* as president. Its major products will be custom-built control and telemetering systems and specialties, mainly directed to the chemical, petroleum, pipeline and gas transmission industries.

HAGAN CHEMICALS & CONTROLS announces that *Matthew Gould* has been named to direct the development of chemical equipment in the Chemical Research and Development Department.

MANNING, MAXWELL & MOORE will build a new valve manufacturing plant in Alexandria, La. The one-story building of approximately 125,000-sq-ft area will be located on a 100-acre site on U. S. Highway 71.

ALLEGANY INSTRUMENT CO., Div. of Textron Electronics, Inc., announces that *James E. Starr* has joined the company as research director.

JAMES E. STARR

HENRY S. BLACK

CONSOLIDATED ELECTRODYNAMICS CORP., a subsidiary of Bell & Howell Co., has combined its DataTape Division and Electro Mechanical Instrument Division into a single, expanded organization to be known as the Data Recorders Division. *Henry S. Black,* director of the DataTape Division the past two years, has been named general manager of the new division.

DAYSTROM, INCORPORATED has signed a long-term contract with Nationwide Leasing Co., Chicago, which will underwrite a nationwide program by which Daystrom customers will be able to lease on flexible terms computers, calibrators, complete process control systems, and x-ray and infrared equipment.

ITT FEDERAL LABS. announces that *Harold R. Terhune,* manager of standards, has been elected president of the Standards Engineers Society.

LABORATORY FOR ELECTRONICS and **EASTERN INDUSTRIES** have entered an agreement by which Eastern will be merged into LFE, pending approval of the stockholders. Eastern will operate as a division of LFE.

GREEN PANTOGRAPH ENGRAVERS

● ELIMINATE DELAYS!
● KEEP YOUR OPERATING COSTS WHERE THEY SHOULD BE!

PORTABLE
40-POUND BENCH MODEL 106
Here is a speedy, economical 2 or 3-dimensional engraver used by thousands of dollar-conscious companies. It features 5 positive, accurate pantographic ratios; ball bearing spindle with 3 speeds up to 14,000 rpm. Is supplied with one copy carrier that accepts all standard master type sizes. Will actually work up to 10" by any width. Height of pantograph and position of cutter are continuously adjustable.

You Make Your Own Engraved Nameplates!

MODEL D-2 HEAVY-DUTY 2-DIMENSIONAL
Pantograph for milling, drilling and engraving.
Vertical adjustment of copy table automatic with Pantograph. Features: unobstructed on 3 sides to take large work; micrometer adjustment for depth of cut; ball bearing construction throughout; spindle speeds up to 26,000 rpm for engraving or machining; vertical range over 10"; ratios 2 to 1 to infinity — master copy area 26" x 10"

NEW
MODEL D2-201 PNEUMATIC ATTACHMENT
for use with Model D2 Pantograph Engraver to rapidly drill holes in printed circuits by tracing templates. Drills as many as 100 holes per minute. Equipped with foot switch; spindle air cylinder; regulating valve and pressure gauge; filter and oiler. It's ready to use as soon as it's attached to an air compressor

Write or call for full details and prices.

GREEN INSTRUMENT COMPANY, INC.
Dept 37, 295 Vassar St.
Cambridge 39, Mass. Tel. ELiot 4-2989

CIRCLE 182 ON READER-SERVICE CARD

INSTRUMENT ENGINEER

B.S. in Chemical Engineering, Electrical Engineering, or Mechanical Engineering. 1-3 years experience in pneumatic and electronic controls in process industries. Experience in electrical distribution, motor control, project engineering in process industries desirable, but not essential.

Please send resume to:
MR. GEORGE F. HENDERSON

SHAWINIGAN
RESINS CORPORATION
Springfield 2, Massachusetts

SHAWINIGAN RESINS

FOR PRECISION LABORATORY OR PRODUCTION TESTING

FREED
1110-AB INCREMENTAL INDUCTANCE BRIDGE

AND ACCESSORIES

Accurate inductance measurement with or without superimposed D.C., for all types of iron core components.

- INDUCTANCE — 1 Millihenry to 1000 Henry
- FREQUENCY — 20 to 10,000 Cycles
- ACCURACY — 1% to 1000 Cycle, 2% to 10KC
- CONDUCTANCE — 1 Micromho to 1 MHO
- "Q" — 0.5 to 100
- SUPERIMPOSED D.C. — Up to 1 Ampere
- DIRECT READING — For use by unskilled operators.

ACCESSORIES AVAILABLE:
1140-A Null Detector
1210-A Null Detector - V.T.V.M.
1170 D.C. Supply and 1180 A.C. Supply.

Send for NEW 48 page transformer catalog. Also ask for complete laboratory test instrument catalog.

FREED TRANSFORMER CO., INC.
1707 WEIRFIELD ST., BROOKLYN (RIDGEWOOD) 27, N.Y.
CIRCLE 183 ON READER-SERVICE CARD

Over 40,000 copies of the 1962
ICS' BUYERS GUIDE
will be distributed to instrument and control equipment and component users. Publication date—October 1961. Be sure your products are represented with complete data in Catalog Ads and free listings. Contact any of our reps, listed on page 372—or write ICS' Buyers Guide, 845 Ridge Ave., Pittsburgh 12, Pa.

ICS ADVERTISERS' INDEX

This index is published as service. Every care is taken to make it accurate, but IC/S assumes no responsibility for errors or omissions.

All-State's Plastic Mfg. Co. 548
Adage Inc. 459
Adams Co., Inc., R. P. 471
Aero Research Instrument Company, Inc. 534
Aerospace Corporation 396
American Chain & Cable Company, Inc., Helicoid Gage Division 529
American Meter Company Incorporated 425
American Optical Company 542
Ampex Instrumentation Products Co. 501
Applied Dynamics, Inc., a Subsidiary of Bowmar Instrument Corp. 443
Associated Research, Incorporated 442
Atkins Technical Inc. 546
Automatic Electric 409
Automatic Switch Co. 403
Automatic Timing & Controls, Inc. 516

B&B Motor & Control Corp. 471
Bailey Meter Company 399
Barber-Colman Company, Wheelco Industrial Instruments Division 418
Bin-Dicator Co. 533
Boonshaft and Fuchs Inc. 542
Bourns, Inc. 412
Bristol Company 420, 441
Brush Instruments, Division of Clevite Corporation 517
Burleigh Brooks, Inc. 541

Cambridge Instrument Co., Inc. 433
Chrono-Log Corporation 507
Clary Corporation 466
Clevite Corporation, Brush Instruments Division 517
Computer-Measurements Company 373
Computer Systems, Inc. 488
Consolidated Electrodynamics 389, 510, 511
Crescent Insulated Wire & Cable Co., Inc. 518
Cubic Corporation 411
Curtiss-Wright Corporation, Princeton Division 535
Custom Component Switches, Inc. 520

Daniel Orifice Fitting Company Incorporated 507
Decker Corporation 376, 377
DeJur-Amsco Corporation 404
Delavan Manufacturing Company 398
Dentronics, Inc. 547
Dialight Corporation 394
Dietert Co., Harry W. 540
Dillon & Company, Inc., W. C. 437
Dimco-Gray Company 548
Dwyer Mfg. Co., F. W. 538

Eagle Signal Company 504
Ebert Electronics Corp. 433
Edison Industries, Thomas A. 374
Eldorado Electronics 383
Electric Regulator Corporation 545
Electro-Mech Corp. 431
Electronic Associates, Inc. 486
Electronic Engineering Company of California 515, 531
Engelhard Industries, Inc. 384, 385
Eppley Laboratory, Inc. 438
Epsco-West a Subsidiary of Epsco Inc. 496
Esterline-Angus Instrument Company, Inc. 395

Fairchild Controls Corporation 378
Fecker Division, J. W., American Optical Company 447
Ferance Construction Co. 548
Fisher Governor Company ..... Back Cover
Foxboro Company 415, 427
Freed Transformer Co., Inc. 550
Fulton Sylphon Division, Robertshaw-Fulton Controls Company 514

GPS Instrument Co., Inc. 495
General Controls Co. ..... Inside Back Cover
Gould Co., J. D. 507
Green Instrument Company, Inc. 549

Hagan Chemicals & Controls, Inc. 410
Haydon Company, A. W. 509
Hayes, Inc., C. I. 500
Hays Corporation 379
Haise Bourdon Tube Company, Inc. 502, 519
Heitz Inc., Karl 397
Helicoid Gage Division, American Chain & Cable Company, Inc. 529
Hermes Electronics Co. 526
Hydro-Aire Division of Crane Co. 532
Hoke Incorporated 405
Hoskins Manufacturing Company 381

Imperial-Eastman Corporation 430, 431
Industrial Electronic Engineers, Inc. 546
Industrial Instruments Inc. 539
INSCO Company, Division of Barry Wright Corp. 444, 445
InstruLab, Inc. 531, 548
Instrument Development Laboratories, Inc. 537
International Instruments Inc. 505

Jones Optical Works, A. D. 533

Kearfott Division, General Precision, Inc. 523
Kernco Instruments Co., Inc. 548
King Engineering Corp. 434
Kollmorgen Corporation 501

Laboratory for Electronics, Inc. 414
Leeds & Northrup 419
Lepel High Frequency Laboratories, Inc. 539
Levin & Son, Inc., Louis 534
Lewis Engineering Company 369
Librascope Division, General Precision, Inc. ..... Inside Front Cover
Ludlow Papers, A Division of Ludlow Corporation 525

Mack Electric Devices Inc. 548
Magnasync Corporation 547
Manning, Maxwell & Moore, Inc. 422, 426
Mansfield & Green Inc. 445
Marsh Instrument Company, Division of Colorado Oil & Gas Corporation 538
Marshalltown Manufacturing, Inc. 544
Martin-Decker Corporation 447
Marx Co., Clarence J. 548
Mason Instrument Company 548
Mason-Neilan Division of Worthington Corporation 386, 387
MASSA, a Division of Cohu Electronics, Inc. 388
Mercoid Corporation 545
Meriam Instrument Co. 440
MESUCORA 424
Mico Instrument Co. 547
Microdot Inc. 413
Minneapolis-Honeywell Regulator Co. 391, 401, 402, 406, 407, 474, 524, 541
Missile Component Cleaning Laboratories 502
Moeller Instrument Company, Inc. 522

Nash Engineering Company 428
Nesco Instruments, Inc. 519
New Hermes Engraving Machine Corp. 505
Non-Linear Systems, Inc. 400
Nuclear Measurements Corp. 546

Offner Electronics Inc. 416

P-W Industries 540
Parker Hannifin Corporation 429
Pennsylvania Fluorocarbon Co., Inc. 543
Philadelphia Scientific Glass Company 548
Philadelphia Thermometer Co. 534
Post Electronic Products, Division of Reid Brothers Company, Inc. 375
Power Designs, Inc. 547
Precision Thermometer and Instrument Co. 471
Pyrometer Instrument Co., Inc. 545

Radio Frequency Laboratories, Inc. 508
Reeves Instrument Corporation 490
Rescon Electronics Corporations 544
Robbins Aviation, Inc. 536
Rosemount Engineering Company 530

Sanborn Company 423
Sensitive Research Instrument Corporation 370
Shawinigan Resins Corporation 549
Servonic Instruments, Inc. 506
Shore Instrument & Mfg. Co., Inc. 546
Skinner Electric Valve Div. 435, 436
Statham Instruments, Inc. 380
Sticht Co., Inc., Herman H. 548
Stromberg-Carlson, a Division of General Dynamics 543
Superior Tube Company 408

Taber Instrument Corporation 533
Tektronix, Inc. 528
Teletype Corporation 421
Tensor Electric Development Co., Inc. 536
Thermo Electric Co., Inc. 521
Trinity Equipment Corporation 503

Uehling Instrument Co. 531
Unerti Optical Co., John 502
United Electric Controls Company 446

Valcor Engineering Corp. 439
Varian Associates 527
Veeder-Root 448

Wallace & Tiernan Incorporated 512, 513
Weinschel Engineering 477
Weston Instruments Division, Daystrom, Incorporated 393
Westronics, Inc. 382

Zeiss, Inc., Carl 397

FOR MORE PRODUCT DATA

CIRCLE THE NUMBER that corresponds to the number appearing with the product reported or advertised in this issue.

PRINT YOUR NAME, title, company, address, etc., clearly, detach and mail. No postage needed.

Every month—thousands of readers turn to and use Instruments and Control Systems' ANNUAL BUYERS' GUIDE to help decide specs and procurement of instrumentation and control equipment, systems, and components.

Plan now to ADVERTISE in the next edition—October 1961. Contact our nearest representative—see list on page 372, this issue.

FIRST CLASS
PERMIT NO. 1441
PITTSBURGH, PA.

BUSINESS REPLY MAIL
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

POSTAGE WILL BE PAID BY—

INSTRUMENTS and CONTROL SYSTEMS
(Instruments Publishing Co., Inc.)
845 Ridge Avenue
Pittsburgh 12, Pa.

3/61

Valid only: In U.S. and Canada; If filled out completely; Until 6-1-61 — March 61

Name ..... Title .....

Company ..... Address .....

City ..... Zone ..... State .....

Principal Product of Your Plant .....

☐ Check for address change. Show OLD address here: .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	321	341	361	381
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	322	342	362	382
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	323	343	363	383
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	324	344	364	384
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	325	345	365	385
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	326	346	366	386
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	327	347	367	387
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	328	348	368	388
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	329	349	369	389
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	330	350	370	390
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	331	351	371	391
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	332	352	372	392
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	333	353	373	393
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	334	354	374	394
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	335	355	375	395
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296	316	336	356	376	396
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297	317	337	357	377	397
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298	318	338	358	378	398
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299	319	339	359	379	399
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400

I&CS PRODUCT INDEX

The following is a handy reference to products (and their reader-service number) reported in this issue. For more information on any product mentioned, circle the corresponding number on the reader-service card.

This index is published as a service. Every care is taken to make it accurate, but I&CS assumes no responsibility for errors or omissions.

Accelerometer, 276
Air Dryer, Filter, 64, 84, 101, 144, 329
Amplifiers, 42, 126, 215, 316, 320
Amplifier, Mechanical, 190
An/Dig Converter, 201, 211, 219, 254
Annunciators, 210, 259
Beryllium Analyzer, 226
Brakes, 83
BW Oscillator, 263
Cable Clamp, 173
Calibration Standard, 3, 50, 86, 109, 145, 281
Camera, 29, 97
Carbon Analysis, 151
Card Reader, 370
Charts, 70, 118
Chart Drive, 73
Chromatography, 256, 371, 372
Cleaning, 99
Clock, 108, 110, 188, 261
Clutch, 83
Colorimeter, 206, 375
Combustion, 257, 262
Computer, Analog, 72, 89, 91, 92, 93, 187, 287, 365
Computer Facility, 1
Conductivity, 149, 270
Connector, 45
Compass, 174
Control Systems, 39, 60, 336, 338, 379, 380
Controller, 223
Counters, 6, 80, 207, 217, 288, 302, 326, 331, 354
CR Tube, 307
Dashpot, 162
Data Displays, 46
Data Reduction, 242, 265, 291
DC Receiver, 355
Dead Weight Tester, 76
Delay, 322, 323
Density, 353
Dielectric Test, 377
Digital Readout, 167, 277
Digital Voltmeter, 40, 213
Displacement, 271
Drill, 140
Engraver, 104, 168, 182
Environmental Test, 382
Examining Table, 387
Filter, 212
Filter Gage, 148
Flowmeter, 106, 113, 231, 243, 344, 345
Force, 246
Force Switch, 66
Freq. Deviation, 247
Frequency Meter, 330, 360
Frequency Response, 186, 327
Function Generator, 145
Galvanometer, 42
Gas Analyzer, 10, 274, 374, 386
Half Adder, 299
Hardness, 165
Hardware, 44
Humidity, 164
Impedance Bridge, 314, 315
Impedance Converter, 238
Incremental Analyzer, 268
Inductance Bridge, 183
Inductance Chart, 200
Induction Heating, 150
Infrared, 100, 222
Insulation Test, 74
Labeling Tapes, 384, 385
Lenses, 153, 203
Level, 35, 134, 198, 199, 227, 324, 344
Load Cell, 229
Logger, 32
Magnetic Tape, 45, 96, 116, 171, 245, 309, 366, 367
Magnetometer, 241
Manometer, 184
Memory, 202, 284, 368, 369
Meter Relay, 250, 278
Microscope, Stereo, 30
Motors, 83
Optics, 100, 139, 153, 378
Optical Comparator, 197, 378
Oscilloscope, 130, 249, 304, 358, 361
Page Reader, 206
Panel Meter, 103, 312
Periscope, 282
pH, 47, 95
Photoelectric Control, 6, 194, 335
Physics Exhibit, 55
Pilot Light, 27
Pneumatic Transmitter, 58
Positioner, 300
Potentiometers, 86, 305, 310
Power Supplies, 170, 252, 279, 306, 308, 321, 328
Preamp, 195
Pressure Control, 77
Pressure Gages, 53, 76, 78, 98, 114, 115, 121, 131, 159, 243
Pressure Regulator, 339
Pressure Sens. Paint, 204
Pressure Switch, 8, 122, 230, 240
Pressure Transducer, 7, 11, 24, 35, 41, 105, 123, 244, 346
Printed Circuits, 319
Printer, 4, 52, 61, 217
Process Control, 39, 51
Programmer, 350
Pulse Generator, 225, 266
Pump, 237, 342, 347
Punch Tape, 290, 367
Pyrheliometer, 67
Pyrometer, 146, 163, 176, 258, 356
Radioactivity, 166, 381
Rebuilt Instruments, 179
Recorders, 5, 13, 23, 25, 26, 28, 31, 33, 47, 49, 54 97, 111, 112, 120, 129, 143, 156, 236, 251, 292, 298, 325, 332, 362
Relays, 38, 63, 85, 157, 161, 180
Resistors, 310
Resolver, 189, 359
Servo, 234, 303
Signal Generator, 272
Slide Label, 384
Sorter, 317
Sound Meter, 280
Spectrum Analyzer, 193
Speed, 69, 138
Speed Reducer, 75
Strain Gages, 43, 191, 348
Strainer, 212
Switches, 311
Tachometers, 172, 177, 178, 260, 283, 352, 353
Teflon Shapes, 158
Telemeter, 56, 196, 296, 337, 364
Temp. Control, 39, 233, 340
Temp. Detector, 2, 7, 35
Temp. Indicator, 160, 216, 301
Terminals, 318
Thermal Conductivity, 10
Thermocouple, 12, 102, 142, 154, 228, 267
Thermometer, 124, 141
Thermostat, 175
Timer, 9, 94, 117, 128, 133, 181, 349, 351
Torque Gage, 269
Torque Wrench, 209
Transducers, 35, 313
Transformer, 232, 235, 315
Tube Fittings, 59, 255
Tubing, 37, 71, 119, 152, 214
Turning Table, 275
Ultrasonic Sensing, 82
UV Detector, 218
Vacuum, 77, 220, 239, 332, 334, 347
Valve, 220, 221, 334
Valve Actuator, 155, 224, 293
Valve, Ball, 333
Valve, Control, 22, 36, 125, 185, 285, 297
Valve, Relief, 57
Valve, Small, 273
Valve, Solenoid, 34, 65, 68, 147, 341
Vapor Fractometer, 373
Vibration, 23, 35, 41, 253, 348, 357
Viscometer, 192,
Voltmeter Calibrator, 135, 289
Voltage Divider, 248, 286
Voltmeter, 40, 213, 294, 356, 363
Weight, 208, 229
Welding, 292
Wire, 142
X-Ray, 376
X-Y, 295, 322

Valid only: in U.S. and Canada; if filled out completely; Until 6-1-61 — March 61

Name ..... Title .....

Company ..... Address .....

City ..... Zone ..... State .....

Principal Product of Your Plant .....

☐ Check for address change. Show OLD address here: .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	321	341	361	381
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	322	342	362	382
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	323	343	363	383
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	324	344	364	384
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	325	345	365	385
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	326	346	366	386
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	327	347	367	387
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	328	348	368	388
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	329	349	369	389
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	330	350	370	390
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	331	351	371	391
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	332	352	372	392
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	333	353	373	393
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	334	354	374	394
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	335	355	375	395
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296	316	336	356	376	396
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297	317	337	357	377	397
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298	318	338	358	378	398
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299	319	339	359	379	399
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400

BUSINESS REPLY MAIL

NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

POSTAGE WILL BE PAID BY—

INSTRUMENTS and CONTROL SYSTEMS

(Instruments Publishing Co., Inc.)

845 Ridge Avenue

Pittsburgh 12, Pa.

FIRST CLASS
PERMIT NO. 1441
PITTSBURGH, PA.

3/61

Look to May 1961 issue of Instruments and Control Systems for expert treatment of this important control topic - - -

• TEMPERATURE MEASUREMENT and CONTROL

ICS' READERS can look forward to a comprehensive display of highly informative and useful data.

MANUFACTURERS of temperature indicators, controllers, and allied equipments and components will find May ICS a particularly valuable medium for their product advertising.

For ad and other details, contact our nearest rep — see list on page 372.

---

for more data on products advertised or reported editorially

1. **CIRCLE THE NUMBER, on one of the cards, that corresponds to the number appearing with the advertisement, new product description or new manufacturer's literature.**
2. **PRINT YOUR NAME, title, company, address, etc. clearly. Unreadable cards defy even punched card machines!**

NOTE: If indicating change of address, be sure to also show OLD address.

Valid only: In U.S. and Canada; If filled out completely; Until 6-1-61 **March 61**

Name ..... **Title** .....

Company ..... **Address** .....

City ..... **Zone** ..... **State** .....

Principal Product of Your Plant .....

☐ **Check for address change. Show OLD address here:** .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	321	341	361	381	
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	322	342	362	382	
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	323	343	363	383	
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	324	344	364	384	
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	325	345	365	385	
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	326	346	366	386	
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	327	347	367	387	
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	328	348	368	388	
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	329	349	369	389	
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	330	350	370	390	
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	331	351	371	391	
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	332	352	372	392	
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	333	353	373	393	
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	334	354	374	394	
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	335	355	375	395	
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296	316	336	356	376	396	
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297	317	337	357	377	397	
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298	318	338	358	378	398	
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299	319	339	359	379	399	
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	

BUSINESS REPLY MAIL
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

POSTAGE WILL BE PAID BY—

INSTRUMENTS and CONTROL SYSTEMS
(Instruments Publishing Co., Inc.)
845 Ridge Avenue
Pittsburgh 12, Pa.

FIRST CLASS
PERMIT NO. 1441
PITTSBURGH, PA.

3/61

YOUR PERSONAL SUBSCRIPTION

What's in it for you?

A clean crisp copy each month and every month, completely free of "other reader" marks—no clip- or tear-outs—no creased, bent, coffee stained, dog-eared (or chewed) pages.

And . . . you get the full benefit of outstanding editorial material—solid application data, uncensored by the scissor-wielding reader "up the list" from you—news that's still newsy—and unbroken "series" continuity.

Your personal subscription

To INSTRUMENTS & CONTROL SYSTEMS will assure you of receiving the important 1960 special features on the following:

APRIL—Flow Measurement and Control

MAY—Temperature Measurement and Control

JUNE—Telemetering

JULY—Recording

AUGUST—Systems and Data Instrumentation

SEPTEMBER—Numerical Control

Enter your personal subscription now—use the postpaid card above.

ATTENTION CIRCULATION: EXPEDITE THIS PERSONAL SUBSCRIPTION

Instruments & Control Systems
845 Ridge Avenue, Pittsburgh 12, Pa.

OK, start my subscription to I&CS for one full year (12 issues) for only $4.00.

☐ Payment Enclosed ☐ Bill Me

Name _____

Title or Position _____

Company _____

Address _____

City _____ Zone _____ State _____

Principal Product of Your Plant _____

FURNISH COMPLETE DATA FOR FASTEST SERVICE. THANK YOU.

BUSINESS REPLY MAIL
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

POSTAGE WILL BE PAID BY—

INSTRUMENTS and CONTROL SYSTEMS
(Instruments Publishing Co., Inc.)
845 Ridge Avenue
Pittsburgh 12, Pa.

FIRST CLASS
PERMIT NO. 1441
PITTSBURGH, PA.

3/61

❶ U-Tube
❷ Well Type
❸ Precision Well Type
❹ Multiple Tube
❺ Inclined
❻ Flow Meter

Not Illustrated:
Tank Gauges
Photo-Manometer Panels
Micro-Manometers

Announcing a complete line of Manometers as Trimount Instruments joins General Controls

Through the acquisition of the Trimount Instrument Company, General Controls now offers a complete line of modern, accurate manometric instruments for every application. This famous product line will continue to be produced to the same high engineering standards that have brought broad acceptance to both Trimount and General Controls in the industrial instrumentation field. And all products manufactured and distributed by the Trimount Instrument Division will be sold and serviced through General Controls' international network of factory branch offices. Also included in the Trimount line are the "Crown" Hydraulic Remote Control Systems and the Electronic Level Indicators/Controllers.

General Controls maintains 44 factory branch offices throughout the United States, Canada and Western Europe. For complete information on any Trimount product, check the yellow pages for your local factory branch or Trimount representative.

Electronic Level Indicators/Controllers
Line includes capacitance type ON-OFF Controllers. Also transistorized linear and proportioning Level Indicators/Controllers, designed for use with liquids, gases and solids – including cryogenic materials.

Hydraulic Remote Control Systems
Self-contained hydraulic systems for positive, infinite positioning of remotely located levers, guides, valves or actuators.

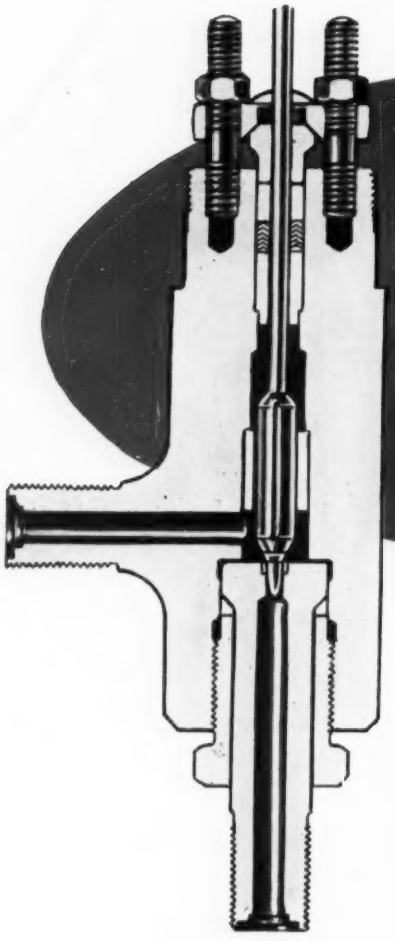
Manufacturers of Manometers, Electronic Level Indicators/ Controllers and Hydraulic Remote Control Systems

TRIMOUNT INSTRUMENT DIVISION

GENERAL CONTROLS CO. 8080 McCormick Boulevard, Skokie, Illinois

CIRCLE 184 ON READER-SERVICE CARD

see FISHER for your

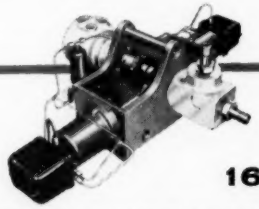


Ultra High Pressure Jobs

When you encounter pressures up to 60,000 psi at 500°F., Fisher can help by designing and producing a high pressure control valve for your specific need • Typical is the Design "C" Body, a hammer forged unit for pressures ranging from 5,000 to 35,000 psi • When required, body forging is heat treated and hardened for added structural strength • Can be produced in Monel, stainless steel, Titanium, and other alloys. Available in a wide variety of high pressure end connections.

470-C

TYPE 470-C utilizes the popular 470 P.O.P. mounted on the hammer forged "C" body. Has received wide acceptance in processing of ammonia and urea. Handles pressures up to 45,000 psi.



16531

TYPE 16531 is a specially designed high pressure control valve for polyethylene let down service. Hammer forged body activated by two powerful 480 P.O.P. actuators which can take independent signals for automatic operation or from manual loading station. Either electrical or pneumatic valve position transmitter.

For complete information on Fisher high pressure control valves send for Bulletin E-500-A.

Fisher Governor Company, Marshalltown, Iowa. Plants in Woodstock, Ont., Rochester, England. Butterfly Valve Division: Continental Equipment Co., Coraopolis, Pa.

If it flows through pipe anywhere in the world ...chances are it's controlled by.....

FISHER® Controls SINCE 1880

CIRCLE 185 ON READER-SERVICE CARD